UNIVERSITY OF CALIFORNIA PUBLICATIONS.

PUBLICATIONS OF THE LICK OBSERVATORY, VOL. IX, PARTS 1, 2, AND 3.

ORGANIZATION AND HISTORY OF THE D. O. MILLS EXPEDITION TO THE SOUTHERN HEMISPHERE.

INTRODUCTORY ACCOUNT OF THE D. O. MILLS EXPEDITION.

DESCRIPTION OF THE INSTRUMENTS AND METHODS OF THE D. O. MILLS EXPEDITION.

SACRAMENTO.

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PART I.

ORGANIZATION AND HISTORY

OF THE

D. O. MILLS EXPEDITION TO THE SOUTHERN HEMISPHERE.

By W. W. CAMPBELL,

Director of the Lick Observatory.

UNIVERSITY OF CALIFORNIA PUBLICATIONS.

PUBLICATIONS OF THE LICK OBSERVATORY, VOL. IX, PART 1.

ORGANIZATION AND HISTORY OF THE D. O. MILLS EXPEDITION TO THE SOUTHERN HEMISPHERE.

BY W. W. CAMPBELL.

While planning the Mills spectrograph and the program of research therewith, in the early 'nineties, I was impressed with the urgent need of radial-velocity observations in the southern hemisphere as well as in the northern. Whether we are concerned with the motion of the solar system through space, or with the structure of the sidereal system, we certainly can not hope to base a satisfactory solution upon radial velocities of the stars confined to one-half or two-thirds of the sky. Let our radial-velocity determinations in the northern hemisphere be as complete and accurate as it is possible to make them: they can not attain their full strategic value until they are supplemented by equally extensive and accurate observations in the southern hemisphere.

It was in 1894 that I first discussed with my colleagues the dispatching of an expedition to the southern hemisphere to secure these observations; and thereafter the subject was constantly held in mind. The time for organizing such an expedition seemed to have come, in November, 1900. With the approval and indorsement of the President of the University, the subject was brought to the attention of Mr. D. O. Mills, the donor of the Mills spectrograph, whose interest in educational and humanitarian subjects has long been an effective power. Mr. Mills most generously offered to provide funds for constructing the instruments, for defraying traveling, erecting, and maintaining expenses, and for the salaries of the astronomers engaged in the work.

It was decided to construct a reflecting telescope mounting to carry the extra 36¼-inch parabolic silver-on-glass mirror which was in our possession, first cutting a hole through the center of the mirror in order that the Cassegrain form of mounting could be utilized. It was known that the mirror was of imperfect figure, and I planned to have the John A. Brashear Company re-figure it after the hole

had been cut. The mirror was shipped to Allegheny in the spring of 1901. Dr. Brashear's tests of the disk of glass showed the existence of strong internal strains, and he reported that the cutting of a central hole would be attended by great risk of breakage. The cutting was begun, upon my responsibility, under precautions against temperature effects or the cramping of the cutting tool. The mirror and tool were immersed in water. The cutting proceeded very slowly, and with frequent and relatively-long periods of rest. The cutting had not gone to any considerable depth, when, during a period of rest, the mirror broke into a multitude of pieces. This in itself was not much of a misfortune, as Dr. Brashear stated that, on account of its enormous internal strains, this piece of glass could never have been made to work well. A new mirror was ordered at once, in June, 1901. The disk was cast with the central hole in place by the St. Gobain Plate Glass Company. It reached Allegheny in the winter of 1901–02. The new disk was for some reason cast about 40 per cent thicker than the old one, but we decided not to cut it down to the original thickness.

The telescope mounting, designed in its general features by me and in its details by Mr. Charles Wooll of the firm Harron, Rickard & McCone, San Francisco, was constructed in the main by the Fulton Engine Works, Los Angeles. It was brought to Mount Hamilton in December, 1901, with the expectation that the mounting, mirrors, clock and spectrograph would be assembled, in the first month of the dry summer following, for exhaustive tests of all the apparatus before shipment to Chile.

A three-prism spectrograph, constructed in our instrument shop from my drawings, embodied the results of many conferences between Mr. Wright and myself. The optical parts were supplied by the John A. Brashear Company. The lenses finally adopted and the prisms, excepting a small section of the prism bases, were shown by Mr. Wright's severe tests to be excellent.

The new mirrors for the telescope were shipped to Mount Hamilton in July, 1902. It was expected that the expedition would sail early in August, and all arrangements were made to that end. The modern steel dome, constructed by the Warner and Swasey Company, was shipped from Cleveland directly to the wharf in San Francisco, late in July; and similarly in the case of other supplies.

When the mirrors were adjusted in the mounting, it was immediately evident that something was wrong. Careful optical measures of the principal mirror established the disheartening fact that the opticians must have used an erroneous formula in figuring it. There was no recourse but to return both mirrors to the makers for correction. I dislike to think of the disorganizing complications which arose, with the mirrors in Allegheny, the dome on the wharf in San Francisco, the mounting uncovered on Mount Hamilton and the rainy season approaching, Mr. Wright's successor and family arriving on the mountain and their quarters not vacant, and so on—*ad infinitum*, it seemed. It was necessary to abandon the

plan for complete tests of the assembled apparatus before sailing. This decision would be culpable under ordinary conditions; and my only purpose in referring to the complications mentioned above is to indicate in part why the decision was forced.

In this connection, I gladly acknowledge the honorable and generous manner in which the John A. Brashear Company assumed the full responsibility for the mistake and set about to correct it. They certainly left nothing undone which promised to further my plans, regardless of whether the expense to themselves would be large or small.

The mirrors were completed in February, 1903. The members of the expedition sailed at once and reached their destination at Santiago de Chile late in April, just at the beginning of the rainy season—which was what I had hoped from the beginning to avoid.

Up to December, 1900, it had been my purpose to conduct the expedition in person. When the Regents of the University at that time assigned new duties to me, a change of plan was necessary. Most fortunately, Mr. Wright, who had assisted me in the work with the Mills spectrograph from August, 1897, was both able and willing to take charge of the expedition. I still expected to accompany the expedition, in order to select the observing station, to install the apparatus and to see the first results. This was prevented almost at the last moment by a severe physical injury received while preparing for the optician's final work on the hyperbolic mirror, and the tests of the two mirrors in combination.

Acting Astronomer William H. Wright, in charge of the expedition, accompanied by Mrs. Wright and by Dr. H. K. Palmer, Assistant, sailed from San Francisco on February 28, 1903.

From Mount Hamilton it is possible to determine the speeds of stars as far south as —30° declination, but in the winter season, especially, it is not desirable to go much beyond —20°. The portion of the sky left for observation from the southern hemisphere is about two-sevenths of the whole. It was believed that the number of stars in the southern region which are as bright as photographic magnitude 5.5, and whose spectra also contain lines capable of accurate measurement under 3-prism dispersion, would lie between 150 and 175. Given a fairly good location, and considering that the expedition would have but one purpose, it was estimated that four satisfactory spectrograms of each star, and a greater number of spectrograms of each star that proved to be binary, could be secured in two years, following the completion of the observing station. When the final plans were made, in 1900, it was not known that the proportion of spectroscopic binaries is so great as it later proved to be.

The question of a satisfactory location for the observing station was a most important one. Peruvian stations are too far north for the program of work undertaken; and, except near sea level, the diurnal range of temperature is large. The

vicinity of Santiago de Chile seemed to be more promising than any other location, taking into account the massive character of the apparatus, the requirements of construction, and the fact that the expedition would probably terminate in less than three years. The weather reports show that central Chile enjoys a fair proportion of clear skies, but that the temperature in Santiago itself undergoes a large diurnal change. However, entire confidence was felt that a very much lower range of temperature would be found on the summits of the hills which spring up to an altitude of a few hundred feet from the floor of the valley on which the city is built; or on a hill, ridge, or divide, affording good atmosphere drainage, along the line of railway joining Valparaiso and Santiago. The advantages of a city near at hand, as a source of material and labor supply during the construction period, were evident. Holding the above important considerations in mind, the choice of the observing station was left to Professor Wright. A month was devoted to the survey and study of the most promising locations. The summit of *Cerro San Cristóbal* was selected. This peak is located at the northeastern edge of Santiago, about 2.3 kilometers from the central plaza of the city. The Observatory site is 920 feet (280 meters) above the *Plaza de Armas*, 885 feet (270 meters) above the foot of the *cerro*, and 2755 feet (840 meters) above sea level.

Notwithstanding the difficulty of installing the Observatory on the mountain in the winter season, the dome, telescope, office building, electric power-line to the valley, and the many accessories were all completed early in October (1903).

The working period of two years terminated in October, 1905. Dr. Palmer returned in September, 1905, and Professor Wright working alone thereafter made a reduced number of observations until the middle of February, 1906, when his successor arrived.

"The spectra* of all the brighter stars south of declination -25° were photographed, and on the basis of the observations thus secured, a working list of 145 stars was made up. This list includes all the stars whose spectra were found to contain measurable lines. Four spectrograms were obtained of practically every star on the list, and additional ones of many other stars were taken for special purposes. The total number of spectrograms secured by the expedition is 800, of which 676 are of stars on the regular list, 92 are of stars whose spectra were found to be unsuitable for accurate measurement, and the remaining 32 are check plates of *Mars*, *Venus*, and the Moon.

"A number of stars were found by Messrs. Wright and Palmer to have variable velocities,—in other words, they were proven to be attended by massive invisible companions. Twenty-two of these binary systems have been announced in the Lick Observatory Bulletins. One case discovered by Mr. Wright is of special interest, as it relates to the first-magnitude star *Antares*. Its variable

*Excerpt from Report of the Director of the Lick Observatory to the President of the University for 1904–06.

velocity was detected by a comparison of Mills spectrograms secured in Chile with Mills spectrograms of the same star secured earlier on Mount Hamilton.

"The work of the expedition was so arranged by Mr. Wright that a majority of the spectra were photographed by him, while most of the measuring and reducing was done by Dr. Palmer. Two hundred and fifty of the spectrograms were definitively measured and reduced in Chile by Dr. Palmer and forty by Mr. Wright.

"Fifty additional plates were measured and reduced at Mount Hamilton by Dr. R. H. Curtiss in the spring of 1905, and 110 in the spring of 1906 by Dr. Palmer,—both these gentlemen being Mills Assistants. The measurement of the remainder of the spectrograms was begun at Mount Hamilton on July 1, 1906, by Mr. Wright and by Dr. Albrecht, Mills Assistant. All should be completed by July of the present year."

In the following pages Mr. Wright gives a valuable account of the activities and experiences of the expedition, with special reference to the working of the instrumental equipment. The subjects discussed are in general those which promise to be useful to other observers engaged in closely related lines of work, including alike those which were entirely satisfactory and those which were capable of further improvement. In reading this account, two facts should be held in mind:

1.—The expeditionary character of the organization. In forming the general plans and in designing the instrumental equipment, I had no thought other than that the work of the expedition would terminate at the end of two years of actual observation, and the instruments be dismounted and returned to this country. The more massive parts of the telescope mounting were kept as light as possible, with a view to their transport to the summit of a hill or mountain that might or might not have a road. Nothing was planned for in the equipment which was not needed in line-of-sight determinations. The requirements of other lines of investigation,—general astronomical photography, for example,—were given no consideration. The dome was covered with heavy canvas (painted) instead of metal, and similarly in other cases.

2.—The successful measurement of stellar radial velocities has been shown by wide experience to be one of the most difficult problems in modern observational astronomy. I had expected that this, the first serious attempt to measure stellar velocities with a large Cassegrain reflecting telescope, involving many radical departures from conventional forms, would develop its own crop of difficulties, to be removed one by one. For this reason, all parts of the telescope were hauled to the summit of Mount Hamilton, and the telescope and spectrograph were completely assembled, preparatory to securing successful spectrograms here,

and to permit the discovery and removal of the anticipated defects and difficulties. In a foregoing paragraph I have explained why this plan was imperatively abandoned. The first assembling and testing of the completed apparatus occurred on the summit of a mountain in Chile, away from instrument makers and machine shops, and it was a great relief to learn that no vital difficulties were encountered. Minor ones there were, but perhaps fewer than anticipated. In fact, no changes of any consequence were made in the instrumental equipment or methods, save by way of temporary experiments.

In the erection of the observatory on *Cerro San Cristóbal* during the rainy season, in meeting and overcoming difficulties as they arose, and in carrying out the program of observation as planned, within the estimated time,* Acting Astronomer William H. Wright, in charge of the expedition, is entitled to great credit. Most important of all, the accuracy of the observations appears to equal that of the observations made with the Mills spectrograph at Mount Hamilton. Notwithstanding many unexpected and extraordinary expenses in securing the mirrors for the telescope, the expenditures were within the originally estimated sum.

It is not customary to publish a statement of the finances of astronomical expeditions, but I venture to think that in the present case this would be of interest and importance to many observers.

My original estimate of expense, approved by Mr. Mills, was $24,000, plus ten per cent for unexpected expenses; total, $26,400. The sum actually expended was $26,075. This provided for the following items:

Telescope, complete with *new* mirrors and driving clock (about $5,500).

Steel dome,† steel track and anti-friction running gear, masonry foundation, wooden walls, floor, and sheathing, and canvas covering.

Three-prism spectrograph complete.

Primary and storage batteries, Ruhmkorff coil, electric meters, electric line one kilometer long from summit to valley, etc.

Office and work-room, dark-room, and outbuildings.

Measuring microscope.

Photographic supplies.

Incidentals and maintenance.

Partial insurance.

Traveling expenses, Mount Hamilton to Santiago and return.

Freight and express.

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*It should be noted that the first year of observation, ending October 31, 1904, was abnormally cloudy, only one year in the preceding forty-three years having had a greater number of cloudy days, according to the records of the Chilean National Observatory, in Santiago. See page 21 following.

†It was expected that this first-class dome, fastened together with bolts instead of rivets, would be brought back for use on Mount Hamilton.

Allowance for dismantling and returning apparatus and dome to Mount Hamilton.

Painting.

Rent of land.

Horse and support.

Labor.

Janitor.

Astronomers' salaries.

The low cost of the Chile $36\frac{9}{16}$-inch reflecting telescope [$5,500 in California] is in striking contrast with the eighteen-fold greater cost of the 36-inch refractor, though I do not doubt that in the same or equally good locations, and with good silver coats on the mirrors, the two instruments would be almost equally efficient in radial-velocity determinations. Necessarily this was the most important factor in making my decision to employ a reflecting telescope. The cost of the dome, walls and moving-floor for the 36-inch refractor exceeded the cost of the dome (including its subsequent iron covering), and accessories for the $36\frac{9}{16}$-inch reflector more than twenty-fold, though it should be said that the structure supporting the Chile dome is on a very modest scale.

The dearth of southern hemisphere observations of the exact kinds that the Mills Expedition is fitted to supply made it extremely desirable that our station should continue in active existence. When the subject was presented to Mr. Mills in 1905, he was pleased to provide for its liberal support through a further period of five years, and for all the several improvements in and additions to the instrumental equipment which the larger plans for the future made desirable. The following list includes the principal items:

The covering of the dome with iron, replacing the heavy painted canvas. (This improvement was made just before Mr. Wright left Santiago.)

A ball thrust-bearing and two roller side-bearings for the declination axis of the telescope.

Apparatus for the quick and convenient silvering of the parabolic mirror.

A mercurial thermostat, to replace the two-metal thermostat on the spectrograph.

A building on the summit to accommodate a machine shop equipped with lathe and smaller tools, driven by electricity; and to contain also two sleeping rooms for the observers.

Telephone connection between the Observatory on the summit and the Astronomers' residence in the city at the foot of the *cerro*.

Two-prism and one-prism spectrographs to permit the carrying of radial velocity determinations to fainter stars.

An extensive refrigerating plant for artificially maintaining the temperature of the large mirror, during the daytime, at the reading estimated for the atmos-

phere on the evening following. (The details for this plant were worked out by Dr. Curtis in the early fall of 1905, during my absence in Europe.)

The cutting of additional holes of considerable size in the mirror cell and in the cubical section of the telescope tube.

An increase of storage capacity for water.

A considerable number of minor additions.

The program of observations during the second period relates to the securing of a greatly increased number of velocities of southern stars covering a larger range of magnitude chiefly for their value in studies relating to the structure of the sidereal universe.

It was decided that Dr. Heber D. Curtis of the Lick Observatory Staff should be Acting Astronomer in charge of the Expedition during this term. Eclipse duties in Labrador prevented him from starting south promptly, and it was arranged that Mr. Wright should remain in Chile three months longer than originally planned, until Dr. Curtis arrived. Dr. Curtis assumed charge of the Expedition on March 1, 1906, and devoted his attention for several months to making the improvements and additions described. Mr. George H. Paddock of the University of Virginia was appointed Mills Assistant at Santiago in succession to Dr. Palmer. He sailed from New York on June 30, 1906. Mr. Wright returned to California in May, to begin active duty at Mount Hamilton on July 1, 1906.

PART II.

INTRODUCTORY ACCOUNT OF THE D. O. MILLS EXPEDITION.

By W. H. WRIGHT,
ACTING ASTRONOMER, IN CHARGE OF THE EXPEDITION.

UNIVERSITY OF CALIFORNIA PUBLICATIONS.
PUBLICATIONS OF THE LICK OBSERVATORY, VOL. IX, PART 2.

INTRODUCTORY ACCOUNT OF THE D. O. MILLS EXPEDITION.

BY W. H. WRIGHT.

The expedition sailed from San Francisco on February 28, 1903, by the Pacific Mail steamship Peru, Captain Trask. The members of the party were Mrs. Wright, her sister Miss Leib, Dr. Harold K. Palmer, and myself. At Panama we changed to the steamer Columbia, Captain Heath, of the Pacific Steam Navigation Company, arriving at Valparaiso, our objective port, on April 18. The trip was accomplished under the most favorable conditions. During the entire period of forty-nine days the water was unusually calm even for these seas, noted for their tranquillity, and the party received many courtesies at the hands of the officers of the steamship companies, and others, which demand grateful acknowledgment. In particular it affords me the greatest pleasure to tender the thanks of the expedition for the efforts of the Pacific Mail Steamship Company, and of its several officers, in meeting all the requirements of the expedition and of the personal comfort of its members.

We met with few adventures during the passage which are not to be accounted normal to travel in those parts of the world, and none that call for record in these pages. Descriptions of the coast voyage may be found in a number of books, and a most delightful account of a journey similar in some respects to ours, written by Professor Solon I. Bailey, is available to astronomical readers in Volume XXXIV of the Annals of the Harvard College Observatory. Progress is deliberate along the West Coast, and Professor Bailey's story of his trip, made in 1889, may be taken as an accurate portrayal of conditions as we found them in 1903.

At Valparaiso we were assisted in landing and in complying with the customs regulations concerning our observatory equipment by the firm of Messrs. William-

son, Balfour and Company, to whom, and to whose agent in this matter, Mr. Wilfred Page, we are indebted for advice and assistance during the first days of our life in Chile. Unfortunately the day of our arrival in Valparaiso marked the outbreak of an extended strike of launch hands, that culminated a month later in a most serious riot, in which a number of business buildings were burned, and over a hundred men are said to have been killed in the streets. During this interval of a month and over, practically no merchandise could be unloaded from lighters, nor moved in the Custom House, nor along the water front. Most of our belongings were unloaded into lighters and left to bob around on the bay. I was fortunate enough, however, to be able to get the mirrors and our telescope, weighing with their packing some nine hundred pounds, into, or rather across the gunwales of a passenger rowboat, and thus balanced we rowed them gently to the shore.

After a few days spent in Valparaiso we went to Santiago, distant about one hundred and twenty miles by rail. Dr. Palmer made a detour through the Aconcagua Valley as far as the town of Los Andes, to see what advantages, if any, that region offered for astronomical observation. We spent a month in Santiago and its vicinity looking over the surrounding country and waiting for the commercial atmosphere of Valparaiso to clear. The city is situated five or six miles from the precipitous slopes of the Andes, or *Cordilleras* as they are more commonly called, on a mountain-locked plain sloping gently toward the west. To the northeast, and towering over the valley, is a fine group of mountains known as *Las Cordilleras de las Condes*, the culminating peak of which, *Cerro del Plomo*, is a magnificent mass of rock over nineteen thousand feet high, and perpetually covered with snow. On all sides are mountain ranges which are of secondary importance only because they are associated with giants. Within the city a number of rocky hillocks rise abruptly from the alluvial deposit upon which the city is built, while to the northeast a long precipitous spur reaches out from the *Cordilleras* and after dipping to the level of the valley rises again and culminates in a hill, somewhat over a thousand feet high, called *Cerro San Cristóbal*. The country surrounding Santiago is made fertile by irrigation and is noted for its productiveness. Vegetation runs riot where unchecked, and vegetables, fruits, flowers, and all manner of produce abound. For a more detailed description of the surroundings of Santiago than we have space to give, the reader is referred to Lieutenant Gillis's report of the United States Naval Observatory Expedition to Santiago (1849–52).

On our arrival in Santiago we were presented, through the kind offices of His Excellency Henry M. Wilson, the American Minister, and Secretary Norman Hutchinson of the Legation, to Señor Don Manuel Foster, Assistant Secretary of Foreign Affairs. Señor Foster had previously been informed of the character of our mission and expressed to us the desire of his Government to aid the work by

CERRO SAN CRISTÓBAL, SANTIAGO DE CHILE.

all means within its power. As a result of this generous disposition on the part of the Supreme Government of Chile many privileges were accorded us, and I must refer briefly to some of these, as well as to a number of courtesies which were shown us by Chileans generally.

All of our freight and baggage, both scientific and personal, was admitted free of customs duties, and the members of the expedition were given passes on the State railroads. Circular letters of introduction from the Minister of Public Works to the station masters of the railroads were also provided, stating the nature of our business in the country, and requesting them to render any assistance possible. Two cars were placed at our disposal for transporting the Observatory equipment from Valparaiso to Santiago.

On the evening of our arrival at Santiago we received a call from Director Obrecht, of the Chilean National Observatory, who extended to us a warm welcome and a courteous invitation to avail ourselves, in case of need, of the resources of the institution under his charge. We had occasion to accept this invitation many times, and are indebted not only to Director Obrecht, but also to Professor Ernesto Greve, First Astronomer, and to M. Krahnass, the Observatory Meteorologist, for the furnishing of certain much needed meteorological data, and for assistance rendered in many other ways.

The Prefect of Police of the Municipality of Santiago offered us the services of a policeman for protection, it having been brought to his attention that the visiting astronomers were in the habit of taking thermometer readings on isolated hills and peaks during the lonely watches of the night. After starting to build the Observatory we were glad to avail ourselves of this kind offer, thereby insuring the safety of Observatory property. This watchman's service has been kept up to the present day. Every afternoon a policeman leaves the *cuartel* in Santiago and climbs the nine hundred feet to the Observatory, returning to the city the next morning.

During the preliminary work, and in fact the entire period of its stay in Chile, our party was under constant obligation to Señor Don Fernando de Vic Tupper, the Honorable Secretary of the Chilean Senate. From the beginning of our residence up to the day of our departure from Chile this gentleman made it his pleasure to facilitate our work, and, with the members of his charming family, to add to the enjoyment of our life among his countrymen. A man of profound knowledge of Chile, and very extended acquaintance by reason of his long connection with the supreme legislative body of the Republic, he held both knowledge and personal influence ready at all times to be used on behalf of the Mills Expedition.

Considerations of space prevent my detailing at greater length the many ways in which the Supreme Government of Chile, the Illustrious Municipality of Santiago, and the Chilean people generally showed their interest in the expedition and its purposes, but enough has been said to indicate the substantial manner in

which they have all manifested their desire to advance the cause of science, and it affords the writer a rare pleasure to extend to them, both on behalf of the expedition and personally, the most sincere thanks.

Our search for a suitable location for the Observatory was interfered with by rainy and generally unsettled weather, though it was still early in the wet season. It is, of course, quite impossible to judge of observing conditions except during normal observing weather, and of this we had little during our first month's residence in Santiago. The Directive Board of the National Observatory and the Director generously offered us the use of a part of the Observatory grounds upon which stood the finished brick walls of a tower of just the size of the one required for our dome, but we were unable to accept this offer, as the great diurnal range in temperature shown by the Observatory records left little room for hope that a reflecting telescope could be used to advantage in that locality.* A number of other sites were considered, and finally the middle peak of *Cerro San Cristóbal*, previously referred to, a long hill about a thousand feet high lying in the northeastern suburbs of Santiago, was chosen as meeting the general requirements of the expedition better than any of the others. Its summit is nearly always well above the dust and haze of the city, and it is free from the ground fog which frequently covers a large part of the valley before dawn on summer mornings. The diurnal range in temperature is much less on the hill than on the plain below, amounting roughly to two thirds of the plain's range in summer and only about a third in winter. The ratio of temperature range during the night on the hill to that in the lower country is about one to three in summer, and less in winter. The following table gives a resumé of our meteorological data for the year ending October 31, 1904. Columns one to five are self-explanatory. Column six gives the mean daily minimum for the corresponding months, taking account of the clear nights only; column seven, the same quantity for the National Observatory, using the same dates; columns eight and nine, the mean diurnal ranges at the Mills and National Observatories, respectively, for these dates; and column ten, the range during the night (from nine o'clock on) at the former place. The corresponding range at the National Observatory is probably about two thirds of the diurnal range. A weekly thermograph record is shown in Figure 3.

It should be stated that the year covered by this table was an unusually cloudy one. Meteorological records have been kept at the National Observatory since the year 1861, and only once since then has such a small number of clear days been observed. In 1898 there were 112, while the next lowest number was 138, in the year 1888. If the ratio of clear nights on the *cerro* to clear days at the *Quinta Normal* as shown by the table may be assumed to hold for other years, there should be, in the long run, some 220 clear nights at the Mills Observatory.

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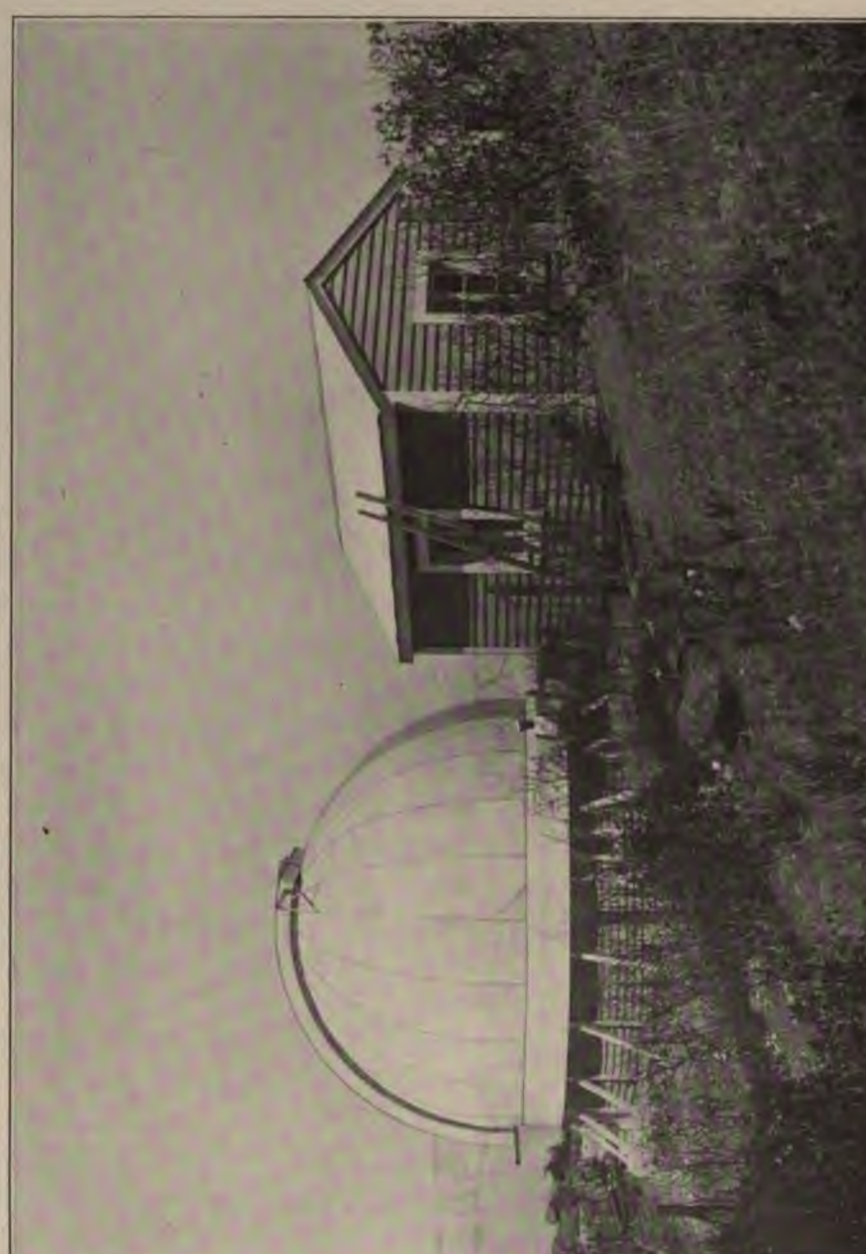
*The National Observatory is located in the *Quinta Normal de Agricultura*, a park in the western (lower) end of the city.



OBSERVATORY OF THE D. O. MILLS EXPEDITION TO THE SOUTHERN HEMISPHERE.

RESUMÉ OF METEOROLOGICAL DATA, SANTIAGO, CHILE, FOR THE YEAR ENDING OCTOBER 31, 1904.

MONTH.	NUMBER OF NIGHTS (CERRO SAN CRISTÓBAL).			Clear Days at National Observatory.*	MEAN MINIMUM TEMPERATURE.		DIURNAL RANGE.		Range During Night (Cerro San Cristóbal).
	Clear.	Partly Cloudy.	Cloudy.		Cerro San Cristóbal.	National Observatory.*	Cerro San Cristóbal.	National Observatory.*	
1903—November . . .	16	5	9	15	13°.7	9°.3	10°.8	17°.1	4°.0
December . . .	16	7	8	19	13 .9	10 .1	12 .5	17 .9	4 .1
1904—January	25	3	3	22	15 .0	11 .3	12 .2	17 .8	3 .6
February	15	4	10	13	15 .1	10 .5	11 .4	18 .5	4 .1
March	17	3	11	18	14 .9	9 .7	10 .7	19 .0	3 .8
April	15	6	9	11	11 .8	6 .3	8 .4	17 .2	3 .8
May	7	6	18	5	10 .6	5 .2	5 .9	14 .8	2 .0
June	6	6	18	5	9 .6	3 .2	6 .8	16 .8	2 .7
July	5	4	22	0	7 .8	3 .5	5 .8	13 .9	2 .9
August	5	7	19	1	7 .8	2 .2	5 .0	15 .5	2 .9
September . . .	8	3	19	5	11 .7	5 .6	5 .7	16 .9	2 .7
October	9	7	15	(7)†	12 .1		7 .5		4 .1
Totals . . .	144	61	161	121					

* Values furnished in advance of publication by the Director of the National Observatory.
† We are not in possession of the National Observatory records for October. The number here given is assumed on the basis of the general ratio between values in columns 2 and 5.

Average number of clear days 1861–1895	197
Average number of clear days 1896–1900	156
Least number of clear days observed in any one year (1898) . . .	112
Greatest number of clear days observed in any one year (1890) . .	255

The strike ended in Valparaiso during the latter part of May. Fortunately none of our equipment had been injured, and we lost no time in transferring it to Santiago and getting the work of construction under way. Ground was broken for the Observatory buildings on May 27, and the installation was completed, with the exception of the electric line to the city, on September 11. Observing was commenced on the latter date, but was suspended for a while during October until the line was completed.

Throughout the period of our residence in Chile we lived in Santiago, and Dr. Palmer and I made daily or nightly climbs to the Observatory. After the first few months a horse was secured to aid in the ascent. This climb was fatiguing, and after a year or so got to be monotonous, but it was necessary, as the hill is rugged and barren and affords no facilities for family life.

As a place of residence we found Santiago delightful. The social life of the city is as agreeable as the surroundings are beautiful, and many of our happiest

recollections are associated with our life there. To the great majority of those with whom we came in contact, both Chileans and foreigners, the work at the Observatory seemed to be a matter of interest, and only rarely did we find any one who did not appear glad to render any needed assistance either to the expedition or to the members personally. A number of such attentions have been noticed in the foregoing pages, but the summary is far from complete, and I wish to thank the following ladies and gentlemen, who among others aided us with advice and assistance:

Hon. Henry M. Wilson, U. S. Minister to Chile until 1905.
Mr. Norman Hutchinson, Secretary of the Legation.
Mr. Edward Winslow Ames, Chargé d'Affaires of the United States in Chile.
The Honorable Secretaries of Public Instruction of the Chilean Government officiating during our stay in Chile.
Señor Don Antonio Huneeus, of Santiago.
Dr. and Mrs. Ira La Fetra, of Santiago College.
Mr. Julius Foster and members of his family, of Santiago.
Mr. and Mrs. Charles Wessel, of Santiago.
Dr. and Mrs. Walter Peters, of Santiago.
Professor Luis Zegers, of the University of Chile.
Señor Don Salvador Izquierdo, of Santiago.
Señor Don Ricardo Matte B., of Santiago.
Señor Don Federico Roth, of Santiago.
Señor Don Marcelino Larrazabal W., of Santiago.
Señor Don Carlos Silva, of Santiago.
Mr. Humberstone, Agua Santa Nitrate Company, Iquiqui, Chile.
Mr. Robert Bruce, of San Francisco.
El Club Nacional del Tiro al Blanco, of Santiago.
Los Padres de la Recoleta Dominica, of Santiago.

The account of the instrumental equipment which follows was written in Santiago during 1905. It is presented here substantially in its original shape, only a number of minor additions, subtractions, and changes in expression having been made.

In closing this brief account of the Mills Expedition I wish to refer to the work of my associate, Dr. Harold K. Palmer. Dr. Palmer accompanied the expedition as Assistant, but in a work of this character, calling for a full expenditure of energy on the part of both of us, our relationship was naturally that of co-workers. The responsibility to the Director of the Lick Observatory rested with me, but the actual work of the expedition was done by us jointly. I take this occasion to express my appreciation of his hearty co-operation.

Mount Hamilton,
February 20, 1907.

PART III.

DESCRIPTION OF THE INSTRUMENTS AND METHODS OF THE D. O. MILLS EXPEDITION.

BY W. H. WRIGHT,
ACTING ASTRONOMER, IN CHARGE OF THE EXPEDITION.

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DESCRIPTION OF THE INSTRUMENTS AND METHODS OF THE D. O. MILLS EXPEDITION.

BY W. H. WRIGHT.

The instrumental equipment of the D. O. Mills Expedition to the southern hemisphere consists of a reflecting telescope $36\frac{9}{16}$ inches (93 cm.) in diameter, Cassegrain mounting, a three-prism spectrograph, an induction coil for exciting the comparison spark, and a Toepper measuring microscope. The telescope is mounted in a steel-framed dome 30 feet (9 meters) in diameter. The buildings of the Observatory consist, in addition to the dome, of an office and various outbuildings. The latter afford storage room, stabling facilities, and shelter for the night watchman.

The installation is located on *Cerro San Cristóbal*, a hill in the suburbs of Santiago. A detailed description of the site of the Observatory will not be taken up at this time. The object of the present paper is to describe the apparatus with which the work of the Observatory is being done, particularly in so far as it differs from that usually employed in the determination of radial velocities of stars.

THE TELESCOPE.

THE OPTICAL SYSTEM.—The optical constants of the telescope are as follows:

D = diameter of silvered surface of large mirror	$36\frac{9}{16}$	inches =	92.9	cm.
d = effective diameter of secondary mirror	$9\frac{9}{16}$	" =	24.2	"
F = focal length of large mirror	210	" =	533	"
l = distance between the two mirrors	155	" =	394	"
f_1 = distance of focus of large mirror back of surface of secondary = $F - l$	55	" =	140	"
f_2 = distance from secondary to focus of telescope	174	" =	442	"
f = virtual focal length of secondary mirror.				

We shall have occasion to refer to the following quantities, in addition to the constants enumerated above:

Diameter of disk of large mirror	$37\frac{1}{4}$ inches	=	94.6	cm.
Diameter of hole in center of large mirror	$4\frac{7}{8}$ "	=	12.4	"
T = thickness of large mirror (at edge)	6 "	=	15.2	"
P = weight of large mirror	557 lbs.	=	252	kilograms.
Thickness of small mirror (at edge) about	$1\frac{1}{2}$ inch	=	4	cm.
External diameter of cell of secondary	$10\frac{1}{4}$ inches	=	26.0	"
Occulting area of web support of secondary	4 sq. ins.	=	25	sq. cm.

The necessity for a knowledge of these quantities more accurate than those here given has not been felt, and precise determinations have therefore not been made. They are more or less subject to variation with changing temperature, the range in the case of f_2 being over an inch.

The large mirror is mounted in a cast-iron cell. The edge support consists of six cast-iron blocks distributed at equal intervals around the mirror, and lying between it and the vertical sides of the cell. The blocks are turned out on the inside face to fit the edge of the glass, and are adjusted to contact with the latter by screws threaded through the sides of the cell. A piece of blotting paper lies between the turned surface of each block and the mirror. This system forms the edge support only, and does not prevent motion of the mirror along the axis of collimation.

The back support is constructed on the plan proposed by Professor Ritchey.* In this system the mirror is considered to be divided into a number† of parts of equal weight, each part being supported by a pan centered below its center of gravity. Three of these pans rest on screws threaded through the back of the cell and serve to fix the plane of the mirror. These we shall call the collimating supports. Each of the remaining pans is counterbalanced so as to exert a force equal to the weight of the section which rests upon it. The reader is referred to Professor Ritchey's article for a complete description of the system.

The nine supports of the Mills telescope mirror are distributed in two circles, six in the outer and three in the inner, the three collimating supports of course lying in the outer circle. Assuming the general scheme of division into parts suggested by Professor Ritchey,‡ the radii of these circles may be computed by the following formulæ:

$$a^2 = -4Ft \pm \sqrt{\frac{2r^4+R^4}{3} + \frac{8Ft(2r^2+R^2)}{3} + 16F^2t^2} = 11.06 \text{ inches}$$

Astrophysical Journal, 5, 143, 1897.

† Professor Ritchey assumes twelve parts. The number adopted in the present instance is nine.

‡ That is by radii, and a circle concentric with the mirror.

$$\rho_1 = \frac{2 \sin \frac{\alpha_1}{2} \left\{ \frac{R^5 - a^5}{20\, F t} + \frac{R^3 - a^3}{3} \right\}}{\frac{\alpha_1}{2} (R^2 - a^2) \left\{ \frac{R^2 + a^2}{8\, F t} + 1 \right\}}$$

(for ρ_2 substitute r for R and α_2 for α_1)

where

R = radius of disk of mirror	= 18.62	inches
r = radius of hole in center of mirror	= 2.44	"
F = focal length of mirror	= 210.	"
t = thickness of mirror at center	= 5.5	"
α_1 = angle subtended at center of mirror by two adjacent supports in the outer circle	= $\frac{\pi}{3}$	
α_2 = angle subtended at center of mirror by two adjacent supports in the inner circle	= $\frac{2\pi}{3}$	
ρ_1 = radius of outer circle of supports		
ρ_2 = radius of inner circle of supports		

The resulting values of ρ_1 and ρ_2 are 14.51 inches and 6.35 inches, respectively. It may be remarked that these values do not have to be determined with great accuracy, and in any ordinary case may be decided upon by inspection.

In details the counterweighted supports differ somewhat from those proposed by Ritchey. The plates do not rest directly on the short arm of the lever, but, as shown in the sectional view (Fig. 1), on a screw which is threaded through this arm from below. A hole drilled in the back of the cell allows access to the screw. By means of this arrangement the position of the lead weight can be set to clear both the mirror and cell after the collimation adjustment has been effected.

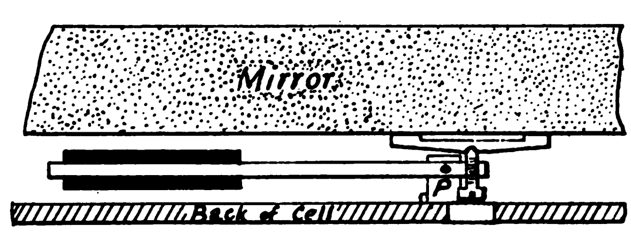

FIG. 1.

The secondary mirror is mounted in a somewhat loosely-fitting cell which is so supported as to allow both a motion along the axis of collimation and a variation in the direction of its normal. By means of these two movements the distance between the two mirrors can be changed, and the secondary mirror can be adjusted in collimation. The secondary support system is held in place by four steel webs, each $\frac{3}{32}$ of an inch by 3 inches (2.5 by 76 mm.), attached to the end of the telescope tube.

THE TELESCOPE MOUNTING.—The general plan of the mounting is the one usually adopted for refracting telescopes. The essential features are shown in

the accompanying photograph (Fig. 2). Two heavy cast-iron plates rest on the two level surfaces of a concrete pier, and are held in place by bolts set in the masonry. These serve as foundations upon which rest the ends of a long hollow casting which carries the bearings for the polar axis. These bearings are bushed with babbitt metal. On the lower plate are vertical lugs, tapped to receive the screws for adjusting in azimuth. The adjustment in altitude is effected by means of screws threaded through horizontal projections from the lower end of the hollow casting.

The polar axis is a hollow cast-iron cylinder. The external diameter is 10 inches, finished down to 9½ inches at the journals. The greater part of the weight which would otherwise come on the upper bearings is taken up by counter-weighted rolls. These rolls are clearly shown in the photograph. The lever and counterweight lie within the hollow casting, just beneath the polar axis. The counterweight is so adjusted as to leave just sufficient weight on the polar axis journal to settle it in its bearing. The force exerted on the lower bearing is not sufficiently great to require the use of rolls.

The thrust of the axis is taken up on a ball-bearing step. As originally constructed, the bearing surfaces of this step were the ground faces of two hardened circular steel plates, one bolted to the end of the polar axis, and the other balanced on a pivot in the central line of the polar axis produced. The second plate was restrained from rotating on this pivot. After considerable experimenting with the instrument set up at Mount Hamilton, this form of bearing was found to offer too much resistance. Ball races were therefore cut in these plates and a ring of ¾-inch balls was supplied. With this simple change, a very easy motion in right ascension was secured.

A cast crossarm, securely fastened to the enlarged head of the polar axis, carries the declination bearings, which are bushed with babbitt metal.

The declination axis is a steel forging, 7½ inches (19 cm.) in diameter. All essential features are shown in the photograph. Wear on the thrust bearing can be taken up by means of an adjustable collar.

There are no anti-friction devices in the declination bearings, and the need of some aid to easy motion in declination is strongly felt. The coefficient of moving friction for the bearings is comparatively small; that is, a motion around the declination axis when once started can be kept up by the application of a comparatively small moment of force. If the motion is continued sufficiently to give a somewhat uniform distribution of oil over the bearing surfaces the resistance is still further decreased. To start the telescope from rest, however, particularly after a repose of a minute or more, requires the application of a larger moment than it is usually convenient to apply. This difficulty manifests itself particularly at large hour angles. The behavior of the bearings is undoubtedly complicated by the fact that the great weight upon them forces most of the oil from

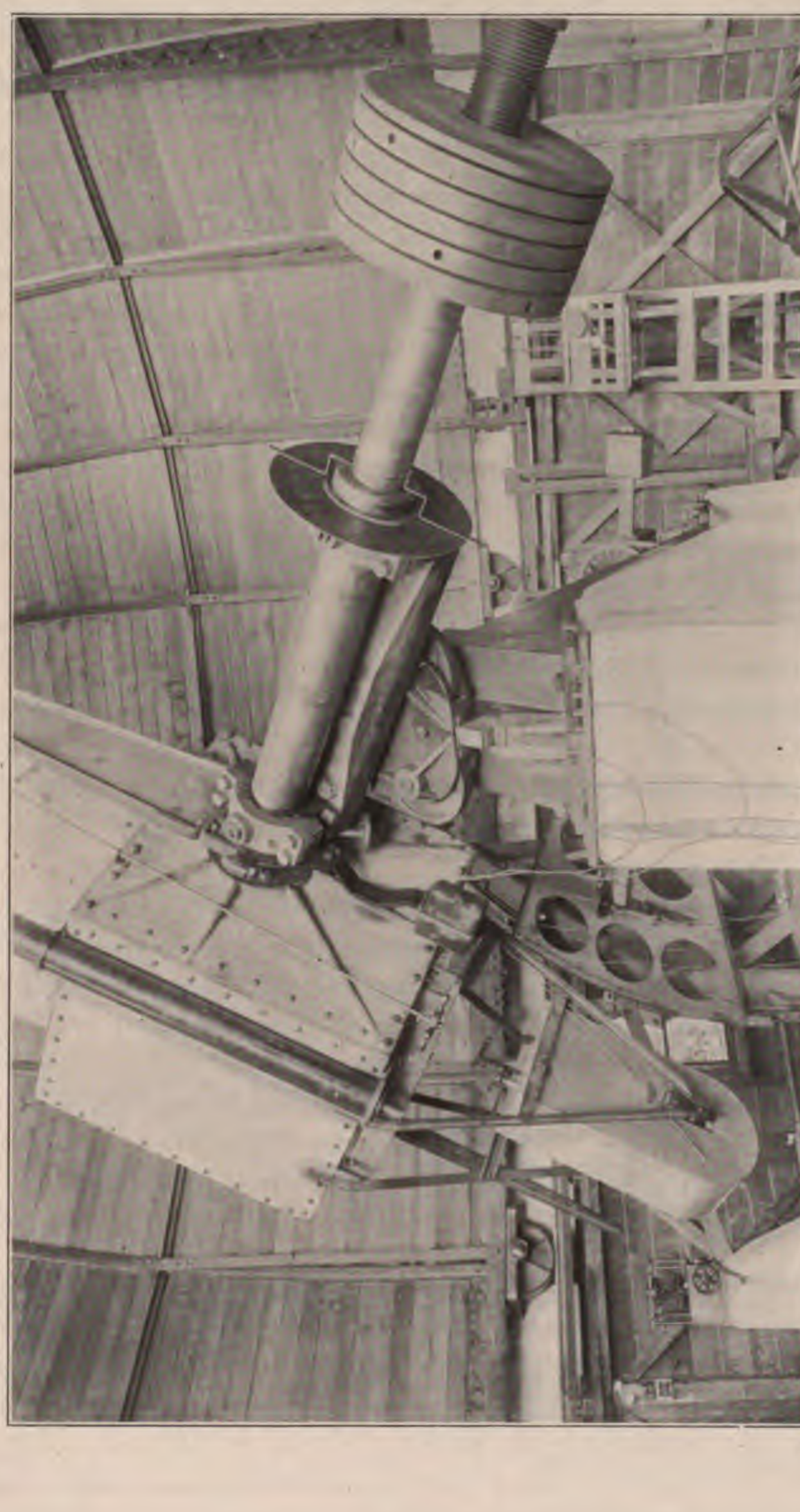

FIG. 2. INTERIOR OF DOME, D. O. MILLS EXPEDITION.

between the bearing surfaces at the points of greatest pressure. The following numerical data are the results of experiment, and will serve to indicate the magnitude of the effects discussed:

1. *Motion in Declination.*—Force applied at a distance of 6.1 feet from the central line of the declination axis:

	Force Applied.	Moment (pounds × feet).
a. Telescope at rest for several hours prior to experiments—		
To start motion	88 lbs.	537
To continue motion	9	55
b. Telescope reversed and moved in declination so as to distribute oil over bearing—		
To start motion	16	98
To maintain motion	4	24
c. After five minutes' rest—		
To start	55	336
To maintain (according as motion is fast or slow),	4 to 16	24 to 98
d. Immediately after reversing to original position—		
To start	12	73
To maintain rapid motion	2	12

In the preceding experiments the hour angle of the telescope was 0^h. For an hour angle of 4^h the force required to start motion after a rest of a few minutes is over 100 pounds, corresponding to a moment of over 610.

2. *Motion in Right Ascension.*—Force applied at a distance of 7.3 feet from polar axis:

To start motion after long rest	26 lbs.	190
To maintain motion	18 to 20	131 to 146

A great amount of time and thought was given by Dr. Campbell to the design of these bearings, and expert advice on the subject was secured. A high mechanical authority with long experience in telescope construction advised parallel bearings unincumbered by anti-friction devices. These would no doubt be satisfactory for machinery in motion, but it would seem that declination bearings should be designed with a view to allowing small displacements of one bearing surface on the other from a state of rest to be made with accuracy.

The magnitude of such displacements made for the purpose of maintaining a star's image on the slit of a spectrograph is of the order of a millionth of an inch. As the strain which produces this motion must be transmitted through a considerable length of elastic material it is an essential condition for smooth mechanical operation that the coefficient of static friction should not greatly exceed that of moving friction. Comparisons between the behaviors of the right ascension and declination axis show this condition to be much more nearly realized by roller and ball bearings than by parallel bearings. It is hoped to improve the declination motion by the substitution of roller bearings for the present ones.*

The slow motion system consists of the usual arm arrangement, operated by a tangent screw opposed to a powerful spring. The arm bears in a V-shaped groove cut around a projection from the declination bearing that is closest to the telescope tube, and is clamped by a wedge-shaped block which is jammed into this groove by a heavy screw. The operation of the slow motion is fairly satisfactory, and with anti-friction declination bearings would doubtless be entirely so.

The section of the telescope tube which is attached to the declination axis is cubical in form, and made up of cast iron and ¼-inch sheet steel. The chief object of giving the section such a shape was to allow room for the raising of the hinged cover of the mirror. To this cube are attached the cylindrical sheet steel tube, the mirror cell, and the "cradle" or framework support of the spectrograph.

The cylindrical tube is of $\frac{1}{16}$-inch sheet steel, reinforced at the section joints by T-shaped steel rings. The length of the tube including the cube is 13 feet 8½ inches (4.2 meters). The form of a closed tube was adopted in preference to that of the open skeleton framework usually used in connection with reflectors, for the double purpose of supporting the secondary mirror as rigidly as possible, and of supplying an efficient dew cap for the protection of the large mirror. These purpose are admirably fulfilled. Such flexure as exists is too small in amount to be appreciable in the field of the finder when setting on a star. As to the accomplishment of the second purpose, our experience has shown that the telescope can be used for work comparatively near the zenith for two or three hours after a fairly heavy dew has commenced to deposit on painted woodwork† outside of the dome. If used for a longer period, dew will usually

*As soon as it was determined that the telescope would remain in Chile for a second period of work, a ball thrust-bearing and two roller side-bearings for the declination axis were designed, at my request, by Professor Curtis, constructed by the builders of the telescope, and shipped to Chile, in January, 1906. The lathe for the new machine shop on *Cerro San Cristóbal* was ordered just large enough to turn out the original babbitted bearings to receive the ball and roller bearings, and Dr. Curtis has personally done the work required in making the change. He has reported the results of his tests of the new declination bearings as follows: "At any hour angle under two hours and at any declination, it takes 6 to 9 pounds to start and 6 to 7 to maintain; * * * At four hours hour angle, 14 to 16 pounds to start and the same to maintain; * * * With telescope 20 minutes 'under' the pier, it takes 3 to 6 pounds to start and maintain."—W. W. C.

†Dew does not form so readily on painted woodwork as on grass and the leaves of plants. On many nights the grass gets quite wet, while no bad effects result from the use of the telescope.

form on the back of the secondary and within the tube, and while only on one or two occasions has it reached the large mirror during the progress of the observations, if exposed under severe conditions the surface is liable to "sweat" after being covered. This result is perhaps connected with the lag of the temperature of the mirror behind that of the air.*

Two advantages of the closed tube have been considered. A disadvantage is that it renders somewhat difficult the burnishing of the large mirror. In order to polish the surface it is necessary to enter the tube, and, except on the driest days, the moisture of the observer's breath and body is sufficient to interfere seriously with the operation of burnishing. Large openings in the sides of the cubical section† would doubtless do much to overcome this difficulty without seriously affecting the rigidity of the mounting.

An objection commonly raised against closed tubes for reflecting telescopes is that air currents are produced within the tubes, which tend to injure the definition. The massive mirror at the lower end of the tube of course retains its heat longer than the thin iron walls of the latter, and convection currents undoubtedly result. It is usually impossible for the observer to differentiate the effects of these from bad seeing. That the atmosphere within the tube is not homogeneous, however, is shown occasionally when the wind strikes the end of the telescope, and eddies are developed around the axis of the tube. These are easily observed by removing the eyepiece and examining the objective by the light of a star. Certain of the irregularities of illumination appear to rotate around the center of the mirror. To what extent the performance of the telescope is injuriously affected by such causes it is difficult to say without experimenting

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*While there can be no doubt that considerable protection is afforded by the tube, it should be stated that even when completely exposed, the mirror seems to resist, comparatively speaking, the deposit of moisture on its surface. During our testing experiments at San Diego, California, dew formed on wood and iron work on every clear night, and although the mirror was without shelter, it was always the last object in the immediate vicinity to collect moisture. This fact was so little in accord with what we understood to be the ordinary experience of observers with reflecting telescopes, that it suggested that possibly the hygroscopic quality of the glass might be an important factor in determining the readiness with which a mirror collects atmospheric moisture. It is well known that different kinds of glass vary enormously in their hygroscopic properties. Certain varieties of glass having valuable optical properties can not be exposed to the atmosphere, under ordinary conditions of humidity, without collecting moisture. It has been noticed by observers at Mount Hamilton that the 36-inch objective fogs over more readily than the 12-inch, a fact that it is difficult to explain on any other basis than that the glass of the former has a greater affinity for water than that of the latter. When we recall that such dew as forms on a mirror eventually raises the silver and lies directly on the glass, and furthermore that certain surface tension phenomena exhibited by water when resting on a silver-on-glass surface indicate that the molecular attraction between glass and water acts to a certain degree through the thin coat of silver, it seems not improbable that what we may call the hygroscopic *intensity* of the glass exerts a strong influence on the readiness with which the silvered surface dews. Experiments bearing upon this subject might possibly be of value in aiding to determine the kinds of glass suitable for specula. The mirrors of the Mills telescope are made of crown glass.

†To overcome this difficulty, several large openings, additional to the one originally there, have been cut by Dr. Curtis. Conveniences have also been provided for easy removal of the spectrograph and mirror, and the mirror burnishing will probably take place in the open air.—W. W. C.

with both open and closed tubes under practically identical conditions.* It is the opinion of the writer, however, that the definition of the telescope could be improved, without seriously affecting its stability, by cutting a sufficient number of holes in the tube to allow rather a free ventilation.

The design of the driving mechanism involves a radical departure from the worm and wheel system usually employed in connection with astronomical telescopes. A heavy steel sector is mounted on the polar axis near its lower extremity. This sector extends toward the west and by its weight turns the axis when clamped to it through the slow-motion mechanism. Underneath the arc of the sector are wheels which run on a circular track. The plane of the track and that of the sector are of course parallel to the plane of the equator. The motion of the sector is regulated by a cord which is paid out by the clock into a groove along the arc of the sector. The sector in this way moves the telescope and drives the clock. The advantage of such a system lies in the fact that a comparatively small and therefore inexpensive clock can be used. The radius of the sector is eight feet, which determines the velocity of the driving cord of the clock to be .0070 inch (.177 mm.) per second. This cord is a steel cable $\frac{5}{32}$ of an inch (4 mm.) in diameter.

The slow-motion in right ascension is produced by a tangent screw and opposing spring which are mounted on the sector and operate on the end of an arm having a clamp bearing on the polar axis. Except in minor details the slow-motion arrangements for right ascension and declination are similar. Each arm is clamped to its axis by means of a block jammed against the axis by a powerful screw.

The following in right ascension afforded by this arrangement is sufficiently accurate for spectrographic work, and was designed by Dr. Campbell with special reference to the needs of this expedition, in which work of this kind only is contemplated. To any one planning for general visual or photographic work, however, the writer would hardly recommend this form of driving mechanism. The following does not compare favorably with that of such a telescope as the great refractor at Mount Hamilton. One objection is the exceedingly slow motion of the clock cord, which means that an excessive tension must be put upon it to give even a comparatively small margin of force over the minimum required to keep up the motion of the clock. In general the rate of a clock will be more uniform if this margin be large. It would be better were the clock driven by a weight falling more rapidly than the sector, with an auxiliary gearing down to the drum which

*Several years' experience with the Crossley reflector fortunately bears upon this question, so far as its relation to Mount Hamilton conditions is concerned, though it should be noted that the temperature variations on *San Cristóbal* are greater than those occurring on Mount Hamilton. The original mounting, in use prior to 1903, had a tube of unusually light and open construction. The new Crossley mounting has an entirely closed tube of sheet steel and cast iron. The two forms of tubes were used by Dr. Perrine for three and two years, respectively; and he has not observed any deterioration in the quality of the definition, since using a closed tube.—W. W. C.

pays out the sector cable.* A further disadvantage of this form of driving mechanism lies in the fact that the elasticity of the clock cord and the *give* in the train of gear wheels within the clock allows the telescope, so admirably rigid in other respects, to be swayed by comparatively light winds, and an arrangement of this sort should not be planned if much wind is anticipated at the Observatory. Fortunately there is seldom any breeze at night on *Cerro San Cristóbal*, during good weather, so that observing is not interfered with by disturbances of this nature. The operation of the clock is not entirely satisfactory. In particular its rate is very sensitive to temperature variations. Its action could doubtless be greatly improved by putting in a seconds pendulum control.

PERFORMANCE OF THE MIRRORS.

The instruments were first tested after being set up on *Cerro San Cristóbal* on the evening of September 11, 1903. On this occasion, and a number that followed, the tests were made before midnight. The optical combination was found to be subject to a very strong zonal aberration of the kind given by an "under corrected" lens, that is, the rays from the outer zones of the mirror were brought to a focus before those from the inner zones. Experiments made during the latter part of the night soon showed that such effects diminished as the night advanced, and the temperature became more nearly constant, and further experience developed the fact that during long periods of constant temperature the zonal aberration disappeared entirely, leaving certain very small and more or less permanent irregularities which will be discussed later. It was also found that the focus of the telescope lengthened rapidly during a period lasting well into the night, the amount of the observed change being from a half to three quarters of an inch.

Some reference should be made at this point to the temperature conditions prevailing at the observing station. Figure 3 shows the temperature for the week ending January 18, 1904. This chart may be taken to represent the normal daily temperature variation during summer weather. It will be seen that the fall is exceedingly rapid up to about nine o'clock at night, when a period of fairly constant temperature begins. During the winter season the diurnal variation is much less, amounting at times to only a few degrees.

METHOD OF TESTING THE FIGURE OF THE MIRRORS.—The following method has usually been adopted in testing the optical qualities of the telescope. The instrument is directed at a star, and the eyepiece of the small telescope, into which the light is reflected from the polished slit plates of the spectrograph, is removed.

*This form of driving mechanism, in which the weight of a long driving sector is the motive power for both telescope and clock, has been a favorite one with all the Lick Observatory eclipse expeditions since 1889. I think that the irregularities in driving referred to by Professor Wright may have had their origin in the revolving pendulum of the clock, and are not peculiar to this system of driving. The Chile pendulum is a duplicate of that on the driving clock of our 12-inch refractor, and the latter has also given trouble. The proportions of the pendulum seem to be not quite right to give a stable rate.—W. W. C.

The observer on looking into the telescope now sees an illuminated area projected on, or beyond, the image lens of the slit telescope, corresponding to the illumination of the objective in the Foucault test. Such errors as may exist in the image lens are not sufficiently great to affect the apparent distribution of light. By keeping the eye at the small telescope, and moving a screen in the focus of the mirrors, the Foucault test can be applied. Convenient screens for motion in right ascension are the edges of the prisms used to limit the length of the slit. In order to get the equivalent of a screen moving in declination, the star's image is thrown to one side of the slit, which is then opened until one edge reaches the image. The slit itself can now be considered a screen which can be operated by a very delicate micrometer screw.

The mirrors have been tested several times during nearly every observing night by the method just described. The combination is practically always "under corrected" (to borrow an optician's term) early in the evening. On only two occasions has the opposite aberration been observed. The difference between the focal lengths of the outer and inner zones of the optical combination is at this time in the neighborhood of three quarters of an inch. During the latter part of the night the figure is better, and, as has been said, the aberration sometimes disappears entirely. The mirror supports have been carefully examined from time to time to make sure that no strain is communicated to the glasses.

Though soon evident that the under correction and focus changes are due to distortions of figure accompanying variations

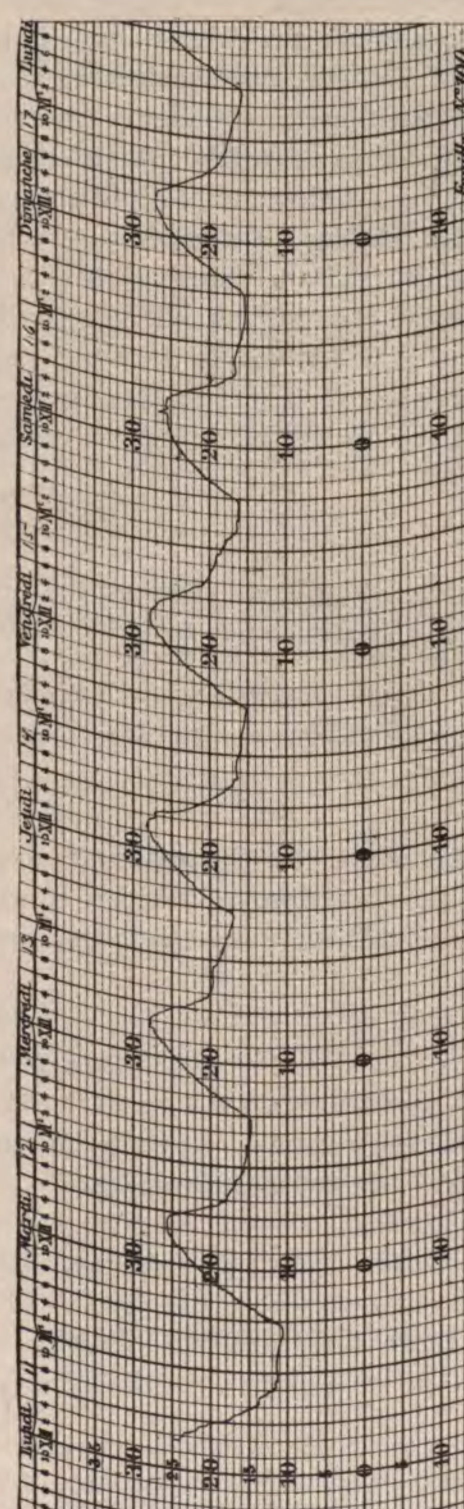

FIG. 3. RECORD OF TEMPERATURE ON CERRO SAN CRISTÓBAL FOR THE WEEK ENDING JANUARY 18, 1904.

in temperature, it was not at once apparent in just what way these variations act to produce the distortions. The fact that the large mirror was cast around a central core may have something to do with its behavior. It can be shown, however, that there is a tendency to an undercorrected form of surface as a result of falling temperature, though to compute the amount of aberration thus introduced would be a difficult matter; furthermore it seems reasonable to suppose that any decided change in temperature tends to cause an abnormal shortening of the focus of the large mirror. A few general considerations bearing upon these phases of the problem will shortly be taken up, but before proceeding further in this direction it will be well to recall a number of elementary relations holding among the constants of a Cassegrain system.

Consider the elementary formula:

$$\frac{1}{f}=\frac{1}{f_1}-\frac{1}{f_2}$$

Differentiating, and assuming the differential relation to hold for such variations as are to be discussed, we have

$$\Delta f_2=\left(\frac{f_2}{f_1}\right)^2\Delta f_1;$$

or, since $f_1=F-l$,

$$\Delta f_2=\left(\frac{f_2}{f_1}\right)^2(\Delta F-\Delta l).$$

If s represents the scale reading which determines the position of the slit in the line of collimation, we may, in view of the fact that the relative positions of the index of this scale and the large mirror remain practically unchanged, assume

$$s=f_2-l+\text{constant}.$$

$$\therefore\ \Delta s=\left(\frac{f_2}{f_1}\right)^2(\Delta F-\Delta l)-\Delta l.$$

If, now, we consider l to vary, on account, for instance, of varying temperature, F remaining constant, we have

$$\Delta s_l=-\left\{\left(\frac{f_2}{f_1}\right)^2+1\right\}\Delta l=-11\,\Delta l.$$

If F varies and l remains constant,

$$\Delta s_F=\left(\frac{f_2}{f_1}\right)^2\Delta F=10\,\Delta l.$$

It is convenient for purposes of discussion to divide the effects of temperature into two classes:

1. Those which depend upon the mean temperature of the instrument, or of one or more of its optical parts; and

2. Those which result from an unequal distribution of temperature through the instrument.

If the temperature varies slowly enough, effects of the first class are all that need be considered. With our telescope, however, working under conditions obtaining on *Cerro San Cristóbal*, those of the second class greatly exceed in magnitude those of the first.

A uniform fall in temperature in all parts of the instrument will cause, through contraction of the material, both a shortening in the focal length of the mirrors, and a shortening in the length of the tube. It is readily seen that were the coefficients of expansion of glass and steel the same, these changes would not alter the position of the focus relatively to the slit of the spectroscope, the only effect being on the scale of the instrument and optical system. Since, however, steel contracts more rapidly with falling temperature than glass, the distance l may be considered to be shortened by an amount:

$$\Delta l = l\,(c_s - c_g)$$

for every degree centigrade of fall in temperature, where c_s and c_g are the coefficients of expansion for steel and glass, respectively. The corresponding value of the change in reading of the scale for setting the slit in the focus of the telescope, which, as it reads in the direction of the axis of collimation we shall call the collimator scale, is

$$\Delta s_l = 11\,l\,(c_s - c_g)$$

assuming

$$c_s = 0.000012,$$
$$c_g = 0.000008,$$

we have

$$\Delta s_l = 0.0068^*$$

inches, for every degree centigrade of fall in temperature.

The above deduction has been made on the basis of a uniform cooling of the whole instrument. As a matter of fact, under ordinary conditions of observation, the mirror is exposed directly after the heat of the afternoon to the action of convection currents and to a certain extent to radiation to the sky, and there is consequently a more or less rapid cooling of the front surface. The effect of the resulting contraction of the front surface on the shape of the mirror must be to render it more concave.[†] If the temperature gradient from the front surface to the back is constant, then the new shape is assumed without sensible strain. The

*For reasons to be referred to later it has not been practicable to determine this quantity by experiment.

†Since this paper was written a number of statements have appeared referring to the experience of observers with mirrors. Ritchey has shown (see article by Hale, *A Vertical Coelostat Telescope. Astrophysical Journal*, **25**, 72, 1907,) that a mirror is bent backward when its front surface is exposed to the sun. This of course results in an increase of focal length, and is the reverse of the effect noticed at night when the front surface is cooling.

amount of the shortening in focal length per degree centigrade of difference in temperature between the two surfaces may readily be shown to be approximately

$$\varDelta F = \frac{2F^2}{T} c_g ,$$

$$\varDelta s_F = 10 \varDelta F .$$

Substituting the numerical values of the various quantities involved, we have

$$\varDelta s_F = 1.2 \text{ inches.}$$

That is, the change in focus corresponding to a difference of 1° centigrade between the temperature of the front and back surfaces of the mirror is 1.2 inches, an amount nearly two hundred times as great as that resulting from a uniform fall of temperature of 1° of the entire instrument.

The above effect has been calculated on the assumption of a uniform temperature gradient from the front to the back surface of the disk. During a certain period following the uncovering of the mirror to the sky, however, such a condition will not in general exist. One would expect rather a rapid fall of temperature from within the mass of the disk toward the cooling surface. Let us suppose a case in which the back two thirds of the mirror is of uniform temperature, while in the front third the temperature falls uniformly from the forward surface of the part just considered to the silvered surface of the mirror. Assume the drop to amount say to 1° centigrade. There would be a strong tendency for the front third of the mirror to become more concave. If this part were left to itself, the increased concavity would be sufficient to cause a shortening of 3.6 inches in the focal length. It is restrained, however, by the back part of the mirror, which tends to maintain its original form. This restraining force must be less efficient at the edges than in the body of the disk where there is less freedom of motion. The surface near the edges (both around the mirror and around the central hole) therefore becomes more concave than the general surface of the mirror, and tends to produce an aberration of the nature of the one observed.

This turning up of the edges has an analogy in nature in the peculiar behavior of the surface of a mud flat which has been exposed to the drying action of the sun.

The arbitrary distribution of temperature assumed above would of course hardly be exactly realized in practice. In view of the complicated conditions of the problem it would probably be impossible to determine, theoretically, the distribution of heat within the mirror. It seems certain, however, that the front surface cools more rapidly, under the conditions of observation, than any other part, and it is accordingly reasonable to suppose that this fact governs the behavior of the mirror.

The effect of a rise in temperature of the air of the dome is doubtless to heat the back of the disk more rapidly than the front, since heat must be conveyed to the mirror chiefly through the agency of convection currents rising from the back

of the cell, and a distribution of heat somewhat similar to that caused by a fall in temperature is produced.

The result of a change of temperature in either direction would therefore appear to be to shorten the focus of the large mirror. A sharp maximum in the daily temperature curve, such as we have on *Cerro San Cristóbal*, followed by a rapid fall, should leave the focus abnormally short, and it is probably the recovery from such a condition, during the uniform temperature of the night, which causes the observed increase in focal length.

It has been found that the variation in focal length can be subjected to considerable control by regulating the ventilation of the space back of the mirror, and the optical performance of the telescope would doubtless be improved by the cutting of a number of holes in the cell in addition to the one already provided* for ventilation.

We have considered the effect of temperature on the large mirror only. The secondary, on account of its small size and exposed position, follows external temperature changes more readily. The disturbing effects of temperature must therefore be comparatively small for this mirror.

Our observing practice is to uncover the mirror to the sky about two hours before sundown, and to allow it to stand until the lapse of an equal interval after sunset. The focus is then found to be lengthening rapidly, the image showing considerable aberration. During the course of the following four or five hours the focus will lengthen from a half to three fourths of an inch. The variation during an exposure sometimes, though rarely, ascends to the latter amount. The range during the second half of the night is usually small, and in fact toward morning the focus will sometimes shorten slightly.

A change of focus was noticed by Professor Keeler while using the Crossley reflector, and was referred to by him in his description of that instrument† in the following words:

"After some further experience with the instrument, still another change was made in the adjustment. It was found that the focus often changed very perceptibly during a long exposure. * * * Why the focus of the telescope should change during a long exposure is not quite clear. The change is much too great to be accounted for by expansion and contraction of the rods forming the tube, following changes of temperature. * * * The observed effect is probably due to the fact that the focal surface is not flat, but curved. During a long exposure, the observer keeps the guiding star, and therefore, very approximately, all other stars, in the same positions relative to the plate; but he has no control over the

*As a result of Professor Wright's experience, Dr. Curtis has cut a number of extra holes,—additional to the central opening and the six small holes back of the adjusting screws on the counterweight-levers. This subject is referred to again in my footnote on page 40.—W. W. C.

† *Astrophysical Journal*, **11**, 340, 1900.

position of the axis of the mirror, which, by changes of flexure, wanders irregularly over the field. The position of maximum curvature, therefore, also varies, and with it the focus of the guiding star relatively to the cross wires, where the focal surface is considerably inclined to the field of view. It is certain that the focus does change considerably, whatever the cause may be, and that the best photographic star images are obtained by keeping the focus* of the guiding star unchanged during the exposure."

There is no reference here to the amount of the change, except that it is *considerable*, nor to its character in other respects; whether, for instance, the focal length always varies in one direction during the night. In view, however, of the fact that a change has been observed in the focal length of the Mills telescope, which is practically free from flexure, it appears likely that the variations in both instruments are due to a common cause,† though in the case of the Crossley telescope the phenomenon is probably complicated by the influences referred to by Professor Keeler.

The slit is adjusted to the focus of the mirror by moving the whole spectrograph in the direction of the axis of collimation. As the amount of free motion allowed the latter instrument is only three quarters of an inch (19 mm.), it is frequently necessary during the course of a night's work to lower the end of the telescope and move the secondary mirror toward or from the large one by means of its screw supports. This is a tedious operation and has made it practically impossible to secure data which might show a quantitative relation between collimator scale readings and temperature changes. A range of focus adjustment of about two inches (50 mm.) should be provided with an instrument of this character, or some mechanism should be added for moving the secondary back and forth by the turning of a hand-wheel so placed as to be readily accessible to the observer. The latter would be the preferable plan, for it would permit an adjustment of the focus during an exposure without moving the spectrograph. No injurious effect whatever has been traced to the motion of the spectrograph, which is accomplished easily and without jarring. It would seem to be preferable, however, to get along with-

* The reference here is evidently to the *character* of the image in the eyepiece.

† Experience with the Crossley reflector seems not to support Professor Wright's views as to the influences of varying temperature. The temperature at Mount Hamilton usually falls rapidly from about an hour before sundown to about an hour after sundown; from this time until sunrise it is remarkably uniform, seldom varying more than 2° centigrade; many times it varies less; and occasionally the temperature rises. The focal variation of the old Crossley mounting was as noticeable at the end of the night, after the temperature had been nearly constant for six or eight hours as at the beginning of the night. Further, the same mirror in the new Crossley mounting in a cell even more massive than the old one, is remarkably constant in focus during the night and from night to night. The cast-iron cell of the new Crossley mounting is heavier than the cell of the Mills telescope, and does not have the 2¼-inch central opening of the latter, which encourages some circulation of air around the Chile mirror. These experimental facts lead me to believe that the central hole in the Cassegrainian silver-on-glass mirror is in some way an important contributor to the phenomena described, or at least that the Chile mirror is peculiarly sensitive to temperature changes. I have asked Dr. Curtis to observe the temperature effects directly in the principal focus of the parabolic mirror, and not in combination with the hyperbolic mirror. His results confirm Professor Wright's, that the change of focal length is due to a change of form of the principal mirror.—W. W. C.

out it if this can be done conveniently. Theoretically a change of focal length of the large mirror should be compensated for by moving the secondary (the moving of the former being out of the question), as the resulting displacement of the foci of the two mirrors is less than when the adjustment is made by moving the spectroscope. This is, however, a matter of little practical moment, as a displacement of one of the mirrors by an inch backward or forward from its theoretical position, corresponding to a range of 23 inches in the focal setting of the spectroscope, introduces an aberration along the optical axis of only .036 inch (1 mm.).*

The general performance of the mirror would be better were it somewhat *over corrected* for a constant temperature. We should then get a better average figure during the night. In this connection we may be permitted a suggestion on a related subject. It is, we understand, the practice of opticians to test their mirrors in a constant temperature room. Would it not in general be better to test them under conditions more likely to be realized in actual practice?

The question of imperfection of the objective is intimately connected with a matter of great importance in spectroscopic work, namely, the homogeneity of the pencil of rays after passing through the slit, or in other words, the uniform illumination of the collimator lens. If, owing to defective figure of the objective, light from some part of it is thrown to one side of the slit, the corresponding part of the collimator lens will, according to the geometrical theory, be dark. This will cause a falling off in theoretical resolving power, which is not always a serious matter, and in addition introduce an inequality in the paths of star and comparison light, which should be avoided if possible.† Poor seeing and imperfect following have tendencies to overcome the second fault by causing to be admitted light from various parts of the image, while diffraction produced by the edges of the slit plays an important part in the distribution of such light as passes through. In order to test the illumination of the collimator the prism box was removed, and a plate holder so secured as to allow a photographic plate to be exposed directly behind the collimator lens. Exposures were made with this arrangement on *Sirius* and *β Crucis* with slit widths of .03 mm. and .04 mm. respectively. Except for the occulting effect of the secondary mirror, the distribution of light is nearly uniform over the entire surface. Both of the negatives show a very slight falling off in intensity in one part of the lens, not sufficiently great to be a serious matter, and probably due to a slight tarnish of the corresponding part of the mirror.‡ Effects of diffraction are shown by the plates and will be considered in the discussion of the spectrograph.

*For formulæ relating to this matter, see the *Supplementary Note, B*, at the end of this article.

† This is a matter of particular importance in practical radial velocity work, as any error resulting from the cause referred to affects only the determinations of stellar velocities, and not those of planetary and lunar velocities, upon which the observer relies to check his results. The reason for this is that with an extended source even an imperfect objective will fill the collimator with light.

‡ Whether this diminution in intensity was due to a local tarnish of the mirror, or to imperfection of the star image, could have been determined by repeating the experiment, using a width of slit sufficient to admit all the light of the star. The defect was not, however, sufficiently serious to require further investigation.

Observers with reflecting telescopes sometimes refer to temperature variation and flexure due to the weight of the disk as joint factors in the production of such disturbances in the figures of mirrors as are observed. While keenly alive to the influence of the first-mentioned agency, the writer, though speaking with some diffidence on the subject by reason of his having had experience with only one mirror, believes the effects of weight flexure to have been greatly overestimated. With the Mills telescope, at any rate, these effects are inappreciable. To test this point the six counterweighted back-supports of the large mirror were loosened by means of their adjusting screws, thereby allowing the weight of the mirror to rest entirely on the three fixed, or collimating, supports. No change whatever was observed in the shape of the surface.

To compute the flexure of a disk of elastic material supported at a number of points would be an exceedingly difficult task. We may, however, fix a maximum angular deviation not likely to be exceeded, nor in fact approached, in practice. Let us assume the extreme case of a disk balanced on a straight edge coinciding with one of the diameters of its lower surface.

The greatest angular deflection will occur at points 90° from the extremities of this diameter, and an expression for its amount can be developed from the differential equation used by engineers in computing the flexure in beams. Such a formula has been deduced and will be found in *Supplementary Note, C*, at the end of this article. Substituting in this expression the constants of our mirror, and calling δ the angle of deflection at the point considered, we have

$$\delta = 0''.38.$$

The resulting deflection of the ray is

$$2\delta = 0''.76,$$

which is certainly a small quantity, considering the extreme conditions of the assumed support. If instead of resting on a straight edge the mirror were mounted on some sort of a support symmetrical with regard to its center, say a ring concentric with the disk or even (in the case of a solid mirror) on a point at the center, the aberration would probably be negligible. In the latter case while the value of δ might be somewhat larger than the one given above, the general tendency of the distortion would be to make the mirror less concave, so that its effect on the image would be largely taken up in the resulting slight increase in focal length. As the aberration in such extreme cases is so small, it is apparent that it must be negligible when the mirror is supported with any degree of care.

It is easily shown that the change in shape of a mirror under its own weight while resting on its edge is inappreciable.*

In view of the above considerations it is evident that the present support system is more elaborate than the necessities of the case demand. It was, how-

* For detailed discussion, see *Supplementary Note, D.*

ever, very easily and cheaply made, and, were the mirror thinner, the full flotation effect of the counterweighted supports might be of advantage in maintaining the figure.

Attention has been called to the unusual thickness of the large mirror. On the whole, this feature is in our opinion a disadvantage. A thick disk is not of course so subject to flexure as a thin one, but with a well-designed support system even very thin mirrors should be free from disturbances of this nature. Comparing now the effects of temperature on thin and thick disks, it is seen that a cooling of the front surface with regard to the back would cause a greater change in the focal length of a thin mirror than in that of a thick one, as the expression for the amount of this change involves the thickness, T, in the denominator. On the other hand, a thin mirror would adjust itself more rapidly to a condition of uniform temperature, and furthermore the spherical aberration introduced by the departure from a uniform temperature gradient between the two surfaces would be less in amount. Any extra thickness of the mirror beyond that required for its proper performance means of course useless weight, and this is a disadvantage when the mirror is being handled in silvering.

When the temperature has been fairly constant for some hours all traces of zonal aberration disappear, but there still remain some very small irregularities of surface of a more or less permanent nature. We say "more or less permanent," for they appear to be less marked during the winter than during the summer. This may possibly be due to the fact that the glass was figured and tested at rather a low temperature, but attention should be called to the fact that the diurnal variation in temperature is comparatively small during the winter months, which may account for the better behavior of the mirror during that time. The result of the chief irregularity is such that when the screen in the Foucault test is moved in a certain direction, the light is cut off from the mirror in a direction at right angles to that of the screen's motion. Combined with this irregularity is a comparatively small displacement (somewhat less than an inch) of the vertex of the parabola from the center of the disk.* These small defects do not appear to rotate when the secondary mirror is rotated. They are certainly affected when the large mirror is rotated, though to what extent has not yet been determined. There seems to be little reason to doubt that they lie in the large mirror.

In order to test the definition of the telescope a number of double stars have been examined visually. The companion of *Antares* stands well beyond the glare of the principal star. The separation is about $3''.2$. The pair γ *Circini* was observed under fair conditions. The components were not completely separated, but the star was easily seen to be double, the estimated position angle being about 65°. It was estimated that under good conditions the components could be resolved at two thirds of their present distance. The stars are nearly equal in brightness,

* See *Supplementary Note, A.*

their common magnitude being about $4\frac{1}{2}$. The separation of the pair appears, from the measurements of a number of observers, to be about $1''.1$. The resolving limit of the telescope for stars of this magnitude is therefore in the neighborhood of $\frac{3}{4}''$. It has been estimated that under the best conditions about seven eighths of the light delivered by the mirrors falls within a circle one second of arc in diameter. A very satisfactory view of *Mars* was obtained on June 1, 1905, using a power of six hundred.

The light efficiency of the telescope has been determined from time to time by comparing the exposure times required to secure spectrograms of the sky of equal degrees of density with the spectrograph used in connection with the telescope in one case and exposed to the sky in the other. It is not usually convenient to remove the spectrograph for the purpose of directing it at the sky, but an incomplete illumination of the collimator lens by direct skylight may be obtained by removing the secondary mirror from its cell, which, with the secondary support system, is built in the form of a ring. If τ_2 be the exposure time necessary to give a certain density, *d*, to the spectrogram under these conditions, and τ_3 the time required to give the same density with a complete exposure to the sky, then

$$\tau_3 = .66\ \tau_2\ ,$$

the numerical coefficient having been determined by actual test. If τ_1 be the exposure time required to secure the density *d* with the apparatus as used normally, then calling the light efficiency of the telescope E, it may be assumed that

$$\mathrm{E} = \frac{\tau_3}{\tau_1} = .66\ \frac{\tau_2}{\tau_1}\ .$$

E is what we may call the *net* efficiency of the telescope, as compared with a perfect instrument having a reflectivity of 1 and no occulting by the secondary mirror. The portion of the beam shut off by the secondary is a ninth of all that can be used by the spectrograph. The expression for the reflectivity of the portions of the mirror actually used is accordingly

$$\mathrm{R} = \frac{9}{8}\ \mathrm{E}$$

Assuming the two surfaces to be equally bright and calling their common reflectivity r, we have

$$\mathrm{r} = \sqrt{\mathrm{R}}\ .$$

In experiments of this nature the telescope is pointed at the south pole, and set at an hour angle differing six hours from that of the Sun. The clock is then thrown in to keep this angle practically constant. As is well known, the light of the sky at a point 90° from the Sun is strongly polarized, and as the light transmitted by a prism spectroscope is polarized to a certain degree in a plane parallel to the slit, the intensity of the spectrum of the sky near the pole, as formed by the spectroscope, will vary with the hour angle of the slit. The plane of polarization

of the sky light is that passing through the Sun, the point of the sky observed and the observer. The position of the telescope for minimum intensity of the spectrum is assumed when the hour angle of the telescope equals that of the Sun. The position for maximum intensity is that which corresponds to an hour angle of the telescope differing six hours from that of the Sun, or what is the same thing, an hour angle of the slit equaling that of the Sun.* The intensity for the latter position is more nearly independent of the position of the Sun with regard to the equator, and undoubtedly suffers a smaller percentage of variation on account of changes in the amount of coarse dust and haze in the atmosphere.

The following determinations of light efficiency will serve to indicate the general performance of the telescope:

Date	r_1	r_2	r_3	E	R	r	Age of Coat	
							Primary Mirror	Secondary Mirror
1904—April 15..	47½*s*	30*s*	....	42%	47%	69%	2 days	4½ months
1905—August 11	51*s*	......	24*s*	47	53	73	3½ months	3½ months

A determination of the light efficiency, for H_γ, of the 36-inch refractor of the Lick Observatory (including the small photographic correcting lens) was made during the latter part of the year 1903 and the summer of 1904 by Dr. Moore,† using a method almost identical with the one described here. Dr. Moore's value is 51 per cent. If we consider only those parts of the reflecting surfaces of the Chile reflector not in the shadow of the secondary mirror, the percentage of incident photographic light delivered at the slit by the two telescopes is about the same.

Although a mirror forms an achromatic image, one does not have to observe very far from the zenith with a powerful reflecting telescope to notice a strong tinge of color bordering the image of a star, due to atmospheric dispersion. This effect of zenith distance is more noticeable with a reflector than with a refractor, as with the latter instrument there is always more or less color about. At a zenith distance of 25° the color is very pronounced. It becomes then a matter of importance, where the following is done with the use of a reflecting slit, to determine the position in the elongated star image at which the slit must be placed in order to allow the greatest amount of light, of the wave-length used, to enter the spectrograph. For the purpose of making such a determination the telescope was pointed at a bright star (*α Hydræ*) whose zenith distance was about 25°. One observer looking into the small finding telescope kept the image of the star from drifting in right ascension, while the other looking into the spectroscope moved the telescope in declination until the brightness of the blue spectrum was at a maximum. The position

*The ratio of the intensities for the two positions varies with the distance of the Sun from the equator and probably to some extent with the amount of coarse dust held in suspension in the atmosphere; it is about as 1 : 2½ or 1 : 3.

† *Lick Observatory Bulletin*, **3**, 42, 1904.

of the slit on the image was then noted by the first observer. In this way it was found that the brightest spectrum resulted when the slit crossed the visually brightest part of the somewhat elongated star image. The experiments were repeated, using the star *α Leonis* at a zenith distance of about 45°. While the atmospheric spectrum was much more pronounced in this case, the result of the tests was about the same. As we are not accustomed to observe at zenith distances as great as that used in the second test, the practice is followed of placing the slit across the visually brightest part of the image.

THE SPECTROGRAPH.

CONSTANTS OF THE SPECTROGRAPH.—The constants of the spectrograph have been determined only approximately. An accurate knowledge of them is not essential to the prosecution of the work, and as the focus determinations on which some of them depend would involve the loss of a night's observing, investigation in this direction has been postponed until the necessary time could be spared from the regular program. The following values are approximately correct:

Collimator lens, focal length of	31½	inches	= 80	cm.
" " clear diameter of	2	"	= 5	"
" " diaphragmed down to	1.69*	"	= 4.29	"
Camera lens, focal length of	21¼	"	= 54	"
" " clear aperture of	2½	"	= 6.3	"
Short camera lens, focal length about	16	"	= 40	"
" " " clear aperture	2½	"	= 6.3	"
Number of prisms	3			

The prisms are made of flint glass, Jena No. 102, which was selected by Vogel and Hartmann for the Potsdam spectrograph.† The indices of refraction for this glass are, according to Hartmann, given by the equation

$$n = 1.6122 + \frac{139.1}{\lambda - 2100}$$

from which the indices of the following lines are found to be

$$H_\beta = 1.6626$$
$$H_\gamma = 1.6744$$

Dr. Palmer's measures of the indices of this glass confirmed Dr. Hartmann's formula.

The refracting angle of each prism is 63° 28′. The dimensions of the prisms are as follows:

	Length of Edge.	Length of Face.
Prism No. 1	$1\frac{15}{16}$ inches = 49 mm.	$3\frac{1}{4}$ inches = 82 mm.
Prism No. 2	2 " = 51 "	$3\frac{1}{2}$ " = 89 "
Prism No. 3	2 " = 51 "	$3\frac{13}{16}$ " = 97 "

* The diameter of the pencil of diverging rays on reaching the collimator lens is 1.73 inches. The diaphragm was made slightly smaller so as to allow for accidental variation in the collimation adjustment of the spectroscope.

† *Astrophysical Journal*, **11**, 400, 1900.

Dr. Hartmann has shown* that if the first prism in the train of a spectroscope be so set that a part of the cylindrical beam of parallel light emerging from the collimator passes beyond its refracting edge, the amount of light thus lost may be more than made up by the diminished absorption in the remainder of the beam.[†] This principle was recognized for a number of years in the construction of various pieces of spectroscopic apparatus at the Lick Observatory, but no attempt was made to calculate the most efficient position of the prism. Using Dr. Hartmann's formulæ the position of greatest efficiency is found to be that which allows a segment of 90°, or one of ¼ inch middle ordinate, to escape the prism's edge. The computed intensity of the transmitted light for this position, as compared with that corresponding to the case in which the whole beam is used, is 1.082. The second and

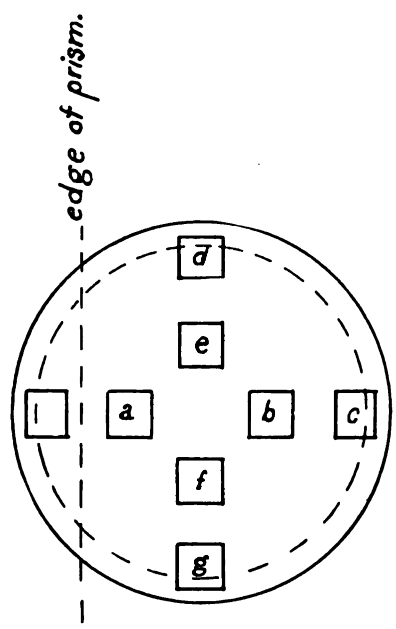

FIG. 4.

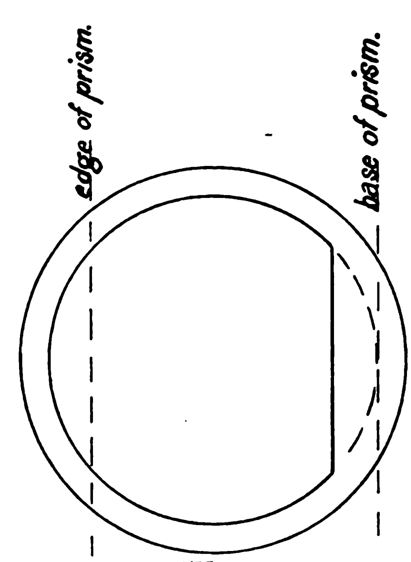

FIG. 5.

third prisms are so placed as to allow the λ 4500 beam, as delivered by the first prism, to pass completely through the optical train.

The collimator lens is a cemented triple, corrected for H_γ. The camera objective first constructed for use with the instrument was of the "isokumatic" type. When the spectrograph was assembled for testing it was found that the field was so strongly curved as to render this lens useless for spectrographic work. The following notebook extracts afford a fairly complete account of the tests: "I mounted the steel frame[‡] of the spectrograph on the 36-inch telescope and focused

* *Astrophysical Journal*, **12**, 30, 1900.

† The proof rests upon the assumption that the beam of light issuing from the collimator lens is of circular cross-section and of uniform intensity throughout. This condition is fulfilled if the slit of the spectroscope is comparatively wide. Narrow slits, however, such as are used in stellar spectrographic work at the present time, so modify the distribution of light in the beam by diffraction as to cause this condition to be very imperfectly realized. See page 49.

‡ To be described later.

the collimator directly on a first type star by Hartmann's method, using a diaphragm ⅞ of an inch wide. * * * The lenses are very thick, the collimator lens being ⅝ of an inch thick at its edge and the camera lens something over ¾ of an inch at its edge. * * * Assembled the spectrograph and determined the focus by means of a diaphragm with holes in it of the size and shape of the sketch* (Fig. 4). Light† from *a*, *b*, *d*, *e*, *f* and *g* comes to a focus at 6.05 (camera scale reading in mm.), while at this reading the light from *c* (from the base of the prism) strikes 0.055 mm. to the violet of the focal point of the other areas. The absorption as shown by the relative intensities of light from *a*, *b* and *c* is very great. The light from the base of the prism may therefore be diaphragmed out without serious loss."

The expedient indicated in the last sentence was adopted in order to avoid the loss of time that would be required to secure new prisms. The diaphragm is of the shape shown in full lines in Figure 5.

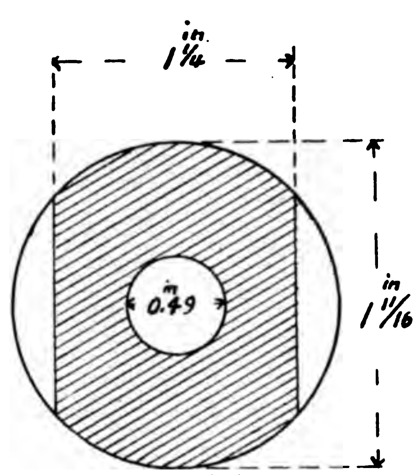

FIG. 6.

The chromatic correction of the "isokumatic" lens used in these experiments is good, the camera setting for H_γ and H_β being the same when the rays are centrally collimated. With the distribution of light given by the prism train, however, the setting for a linear H_δ image was about 6 mm. closer to the lens than that of H_γ, while that for H_β was beyond the adjustment allowance. However, "by looking into the spectroscope it was found that the H_β line, drawn out to great length by astigmatism, could be brought approximately to a focus * * * about 20 mm. further in than the H_γ focus."

As a result of these tests a cemented triple camera objective was ordered from Brashear. This lens gives excellent definition from λ 4200 to λ 4530. Solar or stellar lines are fairly clear from λ 4000 to λ 4600, but beyond the limits first set the comparison lines develop wings. As an example of the definition in the central region of the plate it may be stated that the solar lines λλ 4344.45 and 4344.67 are separated on a "lantern slide" plate.

The shaded area (Fig. 6) shows the effective aperture of the collimator lens. The circular central area represents the projection, or geometrical shadow, of the secondary mirror on the collimator lens. From certain points of view it might seem advisable to diaphragm out this area by a circular screen stuck to the lens, but this has not been done, nor could it be done without losing a certain percentage of light which is spread over the area by diffraction at the slit. Standing as it does

* The diaphragm is indicated by the full lines. Broken lines show the edge of the prism and the section of the beam of light which leaves the collimator.

† H_γ light was used in this experiment.

in the very center of the beam, the comparison light passing through this area probably follows closely the average course of the rays of the stellar light, and, as the parts of the prisms used have been shown to be very homogeneous, there is small probability of error being introduced by the omission* of the diaphragm. The question of diffraction referred to here and also mentioned in describing the performance of the mirrors is one which should receive consideration in the design of spectroscopes, particularly in the arrangement of the diaphragm on the collimator lens. It is the custom of observers to diaphragm the collimator so that the free area is just covered by the cone projected by the telescope objective through the slit. Let *A B* (Fig. 7) be the diameter of such an area. The practice referred to is based on the assumption that the intensity curve of starlight falling on this diameter is represented by a form *A a b B*. This is practically true if the

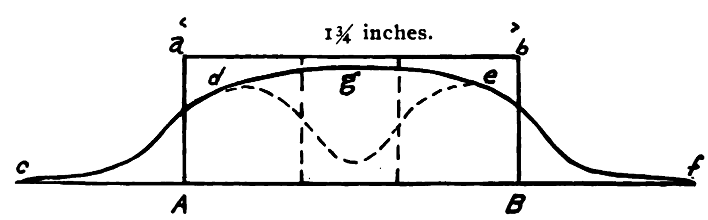

FIG. 7.

diameter is parallel to the slit, but if it be perpendicular to this direction, and if the slit be narrow,—of the order of widths used in photographing the spectra of bright stars,—this condition will not be even approximately realized. The curve *c d g e f* is based on estimates of intensity recorded on a negative† secured using a slit width of .025 mm. The comparison light on the other hand is usually thrown into the spectroscope from an extended area, and the intensity curve in this case is actually of the form *A a b B*. The diaphragm can, then, be considered only a compromise measure, for it neither allows all the starlight to pass, nor insures a similar distribution of intensity in the beams of star and comparison light. If the source to be studied is bright so that light can be spared, the diameter perpendicular to the slit might with advantage be diaphragmed down still further, say to *d e*, provided the resolving power would stand it, while in the case of a faint spectrum an increase in the diameter commonly assumed might be allowable. These remarks bear upon the diaphragm arrangement of the instrument under discussion only as regards the omission of the diaphragm for the central area,‡ as the diameter perpendicular to the slit is heavily diaphragmed for other reasons. If the comparison light could be diaphragmed and accurately collimated before entering the

* Any error introduced in this way, unlike one due to an imperfection of the objective, would affect both stellar and planetary velocities alike, and would thus show itself in the checks.

† The negative here referred to was secured by screening off half of the telescope objective, the edge of the screen being parallel to the slit, and exposing on a bright star, the photographic plate being fastened directly behind the collimator lens. The negative is quite dense at points a quarter of an inch within the geometrical shadow, and about three quarters of the area shaded in Figure 6 was strongly illuminated. Traces of light extended clear across the collimator lens.

‡ The effect of the occulting action of the secondary mirror is to alter the curve in the manner indicated by the dotted lines shown in the figure.

slit, all conditions necessary to insure equality between the paths would be fulfilled without the use of any diaphragm whatever on the collimator lens. An apparatus designed to achieve this end would have to be very rigidly constructed, so as to reduce the danger of accidental displacement to a minimum. We are inclined to think that, with perfect prisms, the light efficiency of the spectrograph would be increased by adopting such an arrangement of the comparison apparatus, placing the prisms in the usual manner, that is, so that the whole circular beam (geometrically considered) would enter the prism train. It is readily seen that Hartmann's formulæ for determining the position of the first prism do not apply to the case under discussion, since his premise of a uniformly illuminated beam of circular cross-section can no longer be assumed.

The construction of the spectrograph differs somewhat radically from that of any instrument of the kind heretofore described, the aim in the design being to reduce the effects of flexure to a minimum. For completeness it may be well to recall the fact that flexures to which a spectroscope is subject can be divided under two heads:

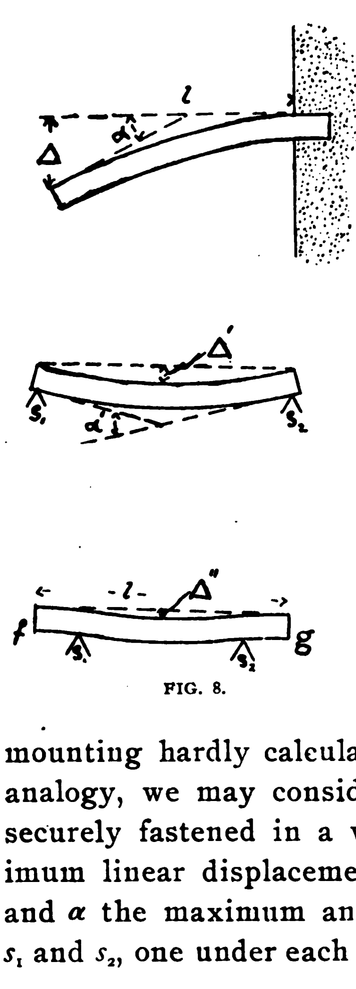

FIG. 8.

1. Flexure of the spectroscope with regard to the telescope; and

2. Internal flexure.

Distortions of the first class affect only the collimation adjustment of the spectroscope and to a less degree the position of the slit with regard to the focus; and, provided these are small, they will have no influence on the observations. Distortions of the second class, however, even though they be comparatively small, are quite capable of interfering seriously with the proper performance of the instrument.

Heretofore most spectrographs have been fastened to the telescope somewhere near the slit end, and have projected outward from their supports, a form of mounting hardly calculated to give a minimum of flexure. As an engineering analogy, we may consider the case of a projecting beam, one end of which is securely fastened in a wall, as indicated in Fig. 8. Let Δ represent the maximum linear displacement due to the bending of the beam under its own weight, and α the maximum angular deflection. By resting the beam on two supports s_1 and s_2, one under each end, the corresponding quantities are reduced to

$$\Delta' = \frac{5}{48}\Delta\,,\ \alpha' = \frac{1}{2}\alpha$$

By bringing s_1 and s_2 closer together the flexure can be still further reduced, there being a value $$f s_1 = s_2 g = \frac{l}{2}\left(1 - \frac{1}{3}\sqrt{3}\right) = .211\, l\,,$$

for which α'' vanishes and $\Delta'' = \frac{1}{208}\Delta$. Under such circumstances the relative positions of two pieces of apparatus, one at f and the other at g, would be unaffected by flexure, or what amounts to the same thing, by the position of the beam with reference to the vertical.

In designing the spectrograph an attempt was made to take advantage of the class of phenomena here exemplified by furnishing the spectrograph with a support near each end. The instrument is shown in Fig. 9. It consists of a ribbed steel casting which, for want of a better name, we shall refer to as the main frame, to which are attached by screws: the slit mechanism, the prism box, and the camera tube. Each one of the latter three parts is independent of the other two.

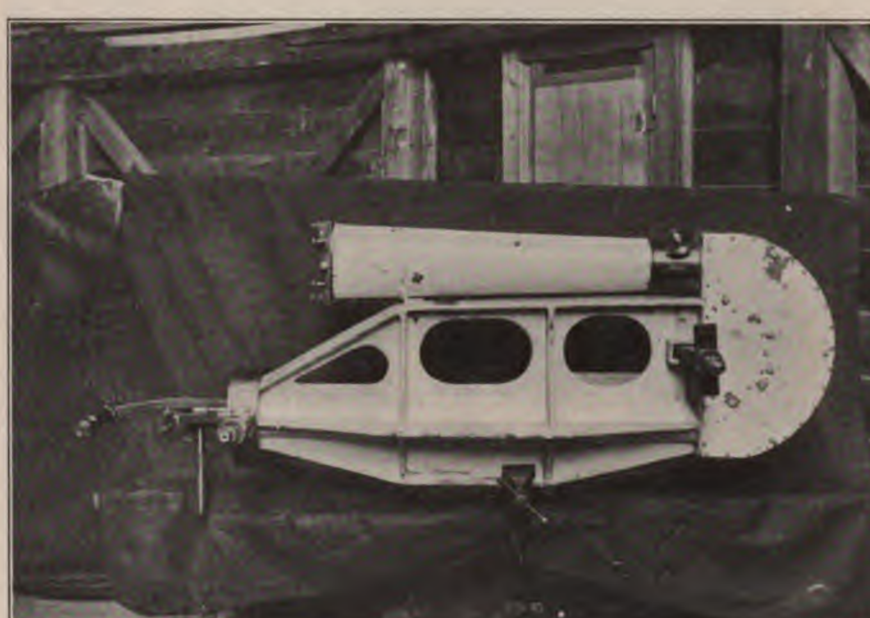

FIG. 9.

The light passes from the slit to the collimator lens through a hole bored lengthwise through the main frame. Near the upper end of this frame, and forming a part of it, is a circular disk at right angles to, and centered on, the axis of collimation. This disk, the edges of which are turned to a spherical surface, fits into a cylindrical brass ring shown in the photograph. The ring forms the forward, or upper, support of the spectroscope, and allows a motion of the instrument along, or rotation around, the line of collimation. The other support consists of a rod swiveled in the main frame close to the prism box. This rod has a free swing through a sufficient angle, in a plane which stands at right angles to the prism box and parallel to the axis of collimation. These supports are themselves held in the framework or cradle of angle irons shown in Figs. 10 and 11.

The ends of the upper rod are fastened securely to the channel iron cross-pieces, while those of the lower rest in slides, which, by means of hand screws shown in the figures, may be moved in a direction parallel to the axis of collimation. By means of these screws, through the motion of the whole instrument, the slit is adjusted to the focus of the telescope.

The prism box is made up of sheet steel reinforced inside by webs. The prisms rest on buttons of hard rubber, which are screwed to one side of the box. These buttons serve as good heat insulators between the glass and metal. The prisms are held in place by hard rubber stops also fastened to the side of the prism

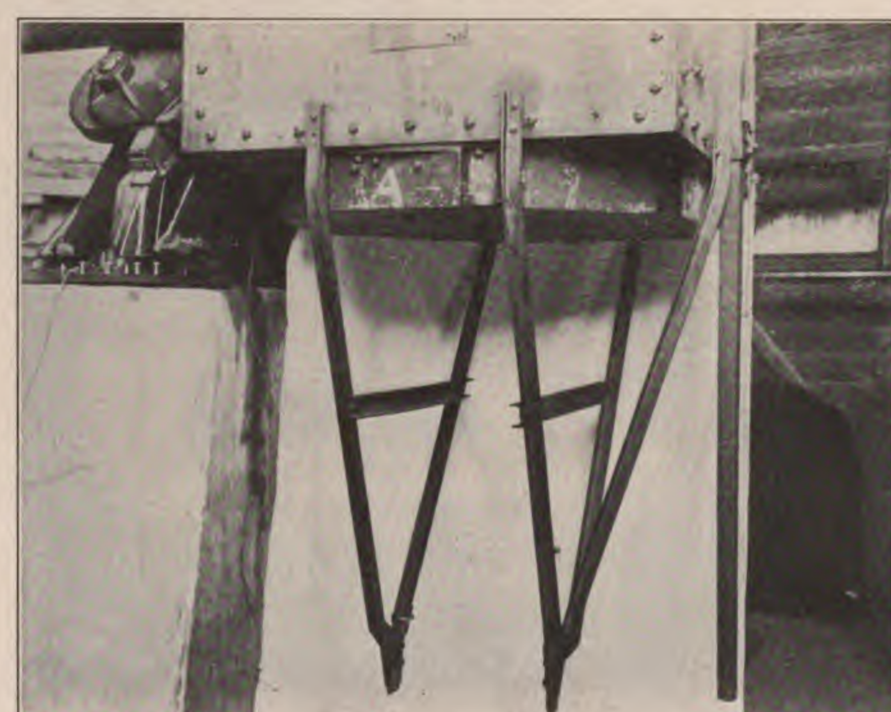

FIG. 10.

box. These stops have to be adjusted with some care to insure freedom from strain in the prisms. The latter are set in their computed places, which are marked on the side of the box, and are not otherwise adjusted for minimum deviation. Flat springs rest against the tops of the prisms, and on these a light pressure is exerted by screws through the opposite side of the box.

The camera is focused by racking the objective along the axis of collimation. The lens is mounted near the middle of a brass cylinder which moves longitudinally in a sleeve. While there may be no good reason for condemning the use of a moving camera objective, our preference, based on experience with both systems, is for a stationary cell as being less liable to strain the lens.

The alignment of the spectroscope in collimation is effected in one direction by means of nuts which secure the ends of the supporting rods in the angle iron framework, and in the other through slotted holes for the screws which hold the two channel irons carrying the upper supporting rod to the rest of the framework.

It will be seen that this system of mounting, while providing supports for the spectrograph at two points, precludes all possibility of any strain being transmitted from the supporting system to the instrument.

FIG. 11.

In order to determine the extent to which the spectrograph is affected by flexure, the spectrum of iron was photographed with the telescope pointed as indicated by the following circle readings:

Hour Circle.	Declination Circle.	Zenith Distance.
0		80° S
0		57° S (pole)
0	33°	0°
0		57° N
0		80° N
3	33°	
6	33°	

The total range in the recorded positions of the lines for all of these exposures lies within 0.01 of a revolution of the micrometer screw of the engine, or a matter of 0.0025 mm. The corresponding amount in tenthmeters at H_γ is 0.026. This is a quantity not greatly in excess of the probable error of measurement of a line and as the displacements appear to vary with the time at which the exposures were made, rather than with the position of the telescope, they are doubtless the result of temperature changes* and not of flexure. As the comparison spectrum is photographed at intervals during every observation such small displacements, whatever their origin, are of no consequence whatever, and so far as practical observation is concerned the spectrograph may be said to be free from flexure.†

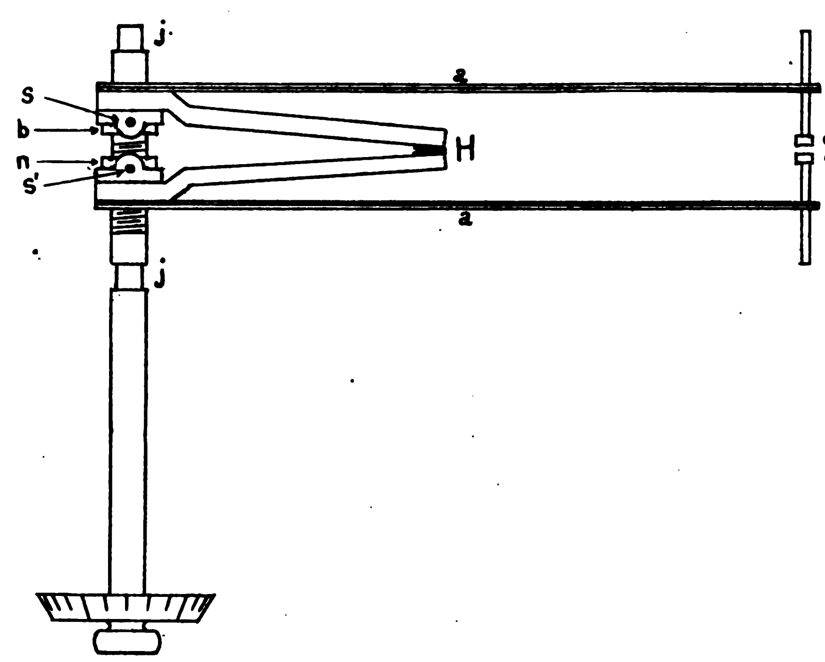

FIG. 12.

A double aluminum case filled in with felt goes over the instrument, the neck carrying the slit mechanism alone projecting through a hole cut for the purpose. This case rests on the two cross rods which support the spectrograph, between which and the case there is no contact. Constant temperature is maintained by an electric current which passes through wires strung inside the lower half of the case. The circuit is opened and closed by a key automatically operated by a thermostat placed close to the prism box. The essential parts of the thermostat are shown schematically in Fig. 12. *a a* are two strips six inches long by one inch wide, each made up of a sheet of brass and one

* These experiments were made in the daytime when the electric current was not available for maintaining the spectrograph at a constant temperature.

† The great rigidity of this instrument leads us to believe that a grating spectrograph, similarly mounted, with a grating support worked out along the lines of Professor Ritchey's mirror support system, would be practically undisturbed by flexure.

of steel soldered together. These strips were made by the Draper Manufacturing Company, and are similar to those furnished by that firm with its recording thermometers. The brass sides face each other, so that a fall in temperature of the strips causes contact of the platinum points *c c*. There is a hinge at *H*. The screw *M* works in a collar *b* and a nut *n* swiveled respectively at *s* and *s'* and by turning it the points *c c* may be adjusted to contact. Two spiral springs (not shown in the sketch) join *s s'* and take up lost motion. The screw *M* runs in bearings *j j* and carries the rest of the apparatus, which is prevented from rotating around the screw by suitable guides placed at *H*. The points *c c* close a relay circuit, which in turn closes the 110-volt circuit by which the instrument is heated. It is possible to send the heating current directly through the points *c c*, but the present plan was adopted for the purpose of reducing the probability of trouble arising from a short circuit of the heating current around the thermostat. The wire which carries the heating current is of German silver, No. 32 Brown and Sharpe gauge (diameter = .00795 inch), the resistance per foot of which is 2.041 ohms.* The case contains about two hundred feet of wire, divided into two sections, which can be thrown in series or in parallel with each other as necessity requires.

The operation of the thermostat is unaffected by varying flexure of the strips when the telescope changes its position, as both of the strips are affected similarly. If for any reason one strip is more rigid than the other, a small weight may be added at its extremity to equalize the behavior of the two. The apparatus performs satisfactorily, the temperature in the prism box seldom varying more than ¼° centigrade during the night. It is absolutely necessary to have some sort of temperature regulation for work under conditions which obtain on *Cerro San Cristóbal* during the summer time. The necessity is due not so much to the variation of temperature during the night, as to the heavy fall which takes place in the late afternoon and early evening. Occasionally our commercial electric current has been cut off, and attempts have been made to get along with no control at all. It has been found impossible to do so. In one case, where the conditions were fairly good, the displacement of the spectrum during the exposure corresponded to a velocity of 50 km. per second. The effect of falling temperature is of course to shift the spectrum toward the red, the amount of this shift per degree centigrade in various parts of the spectrum being as follows:

	Displacement per Degree Centigrade.	
λ	In Revolutions of Micrometer Screw.	In Tenthmeters.
4273	—0.100	—0.23
4326	—0.093	—0.24
4415	—0.083	—0.24

*The constants of this wire were kindly furnished by Professor Cory, head of the Electrical Engineering Department of the University of California.

The effect of temperature on the linear dispersion (as measured with the microscope) is quite marked, the dispersion being less for a low temperature than for a high one. The amount of the change is $+0.039\%$ per degree centigrade. The range of temperature on which these figures are based is from 16° to 26° centigrade.

Temperature changes affect the focal adjustment of the spectrograph to an appreciable extent, the effect of falling temperature being to shorten the focus about 0.02 mm. per degree centigrade. Reliable determinations of focal setting can be made only after the instrument has remained at a constant temperature for some hours.

The comparison spectrum is photographed by means of an arrangement of reflecting prisms described in a previous article.* The spectrum of iron is used for comparison purposes, and is photographed four times during an exposure. By means of a diaphragm the strong lines at λλ 4271, 4308, 4325, 4384, 4405 and 4415 are cut out during two of the exposures. The remaining two exposures are so short that these lines only are recorded.

Guiding on the star is accomplished with the aid of a reflecting slit and small observing telescope.

The camera originally planned for use with the spectrograph was about 21¼ inches long. A few weeks of experience developed the fact that unusually long exposures were required to secure negatives of a satisfactory density, and a camera lens having a focal length of about 16 inches was ordered from Brashear. This was received and mounted in our instrument in March, 1904, and its definition was found to be excellent from λ 4250 to λ 4500. For some reason, however, the definition deteriorated rapidly, and when removed after some three months of use its performance was not at all satisfactory. The original lens was replaced, and an attempt was made to shorten the exposures by utilizing the brighter region of the spectrum to the red of that which had been central in the camera. For this purpose the prisms were adjusted for minimum deviation of the ray λ 4450, and the camera was moved so as to admit that ray centrally. The selection of the wave-length λ 4450 was the result of a compromise between our desire to use a region of still greater wave-length and our unwillingness to use the lenses for wave-lengths differing by too great an amount from the one for which they are corrected. Observing was continued with the spectroscope thus modified for about four months. The comparison spectrum used was that of titanium, as in this region the iron spectrum is poor The exposures were shortened somewhat by the change, though not so much as it had been expected they would be. On the other hand the definition was not so good as under the original conditions of observation, nor was the comparison spectrum so satisfactory. The new region

* *The Auxiliary Apparatus of the Mills Spectrograph for Photographing the Comparison Spectrum. Astrophysical Journal*, **12**, 274, 1900.

was consequently abandoned in favor of the old, and our endeavor has since been to keep the exposure times as short as possible by frequent resilvering of the mirrors.

The exposure time in any given case depends of course on atmospheric conditions, the state of the mirrors, the slit width used, the accuracy of the guiding, and the brightness of the star. Pickering has established a scale of magnitudes by which the brightness of the spectra of stars in the $H\gamma$ region is indicated. A star of fifth magnitude on this scale can, under good observing conditions, be photographed in two hours, using a slit 0.042 mm. wide. As the stars on our observing list run to more than half a magnitude fainter than this, and as observing conditions, instrumental and atmospheric, are not always of the best, it is sometimes necessary to carry our exposures on the faintest stars to four hours.

It has been found best to silver the mirrors every two months. This may seem to be rather often, but the practice of frequent resilvering has commended itself by the superiority of the results secured when it has been resorted to. If the large mirror could readily be burnished a longer time might perhaps be allowed to elapse before replacing the coat, but this operation is a little difficult with the mounting in its present shape. We are inclined to believe, however, that under any circumstances, where it is essential to keep the exposure times as short as possible, the old silver should not be allowed to stand too long on the mirrors. This is the more important if there are two reflecting surfaces instead of one.

In order to ascertain the amount of light lost at the slit (including loss by diffraction) under ordinary observing conditions, a series of spectrograms of the northern component of γ *Virginis* was secured, using various slit widths as follows:

1. Narrow slits such as are used in ordinary observing.
2. Slits wide enough to admit practically all the light of the star.

The amount of light lost at the slit as indicated by these experiments is much greater than one would expect, judging by the apparent size of the image. Under fairly good observing conditions it takes about eight times as long to secure a given density of spectrum using a slit 0.04 mm. wide as is required with the use of a wide-open slit. This means that about seven eighths of the incident light is lost by occultation and diffraction. It would be interesting to learn the corresponding figures for other telescopes and spectroscopes.* This is a matter which bears directly on the proportioning of spectroscopic apparatus, and the tests are readily made in a few minutes.

It is generally recognized that modern spectrographic apparatus is wasteful of light, though to what extent this is so is perhaps not always appreciated. We have at hand sufficient data upon which to base a fairly trustworthy estimate of the general light efficiency of our apparatus. In the following table the figures in the right-hand column represent the percentages of incident light *remaining* after

*Preliminary tests made under rather unfavorable observing conditions indicate that approximately the same proportion of light is lost in the case of the 36-inch refractor and Mills spectrograph.

allowing for the sources of loss placed opposite them. The final efficiency of the apparatus is the product of all of these percentages:

After loss at mirrors and occulting action of secondary	47 %
After loss at slit, including loss by diffraction, poor image, bad centering of image on slit	12½ %
After loss by reflection and absorption in prisms*	26 %
After loss by reflection and absorption in collimator and camera lenses, ⅝ and ¾ inches thick, respectively†	65 %
After incidental losses: diffraction by secondary supporting webs, loss due to diaphragming out imperfections in prisms, etc.	90 %
Resulting light efficiency of apparatus	0.9 of 1 %

Of the two equipments, that at Mount Hamilton with the original Mills spectrograph[‡] and that in use in Chile, the former has the greater light efficiency. A good spectrum of *Mars* at opposition is secured at Mount Hamilton in 40 minutes with a slit 0.0012 inch wide. At the southern station it is necessary to expose 80 minutes using a slit width of 0.0014 inch to get the same density. Practically this same ratio holds for stars when observing conditions are at their best. Before comparing these figures directly, however, it is necessary to take into consideration the optical constants of the two systems. They are as follows:

	36-inch Refractor and Spectrograph.			Apparatus of Mills Expedition.		
Area of telescope objective exposed .	$a_1 =$	1018	sq. inches	$a_2 =$	959	sq. inches
Focal length of telescope	$F_1 =$	58	feet	$F_2 =$	55.4	feet (equivalent)
Focal length of collimator	$\vartheta_1 =$	28.1	inches	$\vartheta_2 =$	31.5	inches
Focal length of camera	$\lambda_1 =$	15.9	inches	$\lambda_2 =$	21.2	inches
Linear dispersion at $H\gamma$ (mm. per t. m.)	$d_1 =$	0.0797		$d_2 =$	0.0964	
Width of slit used	$w_1 =$	0.0012	inch	$w_2 =$	0.0014	inch

From the point of view of optical proportions the ratio of the brightness of the spectrum formed by the Chilean spectrograph to that given by the Mount Hamilton instrument should be, for an extended light source,

$$\frac{a_2 \, F_1^{\,2} \, \vartheta_2 \, \lambda_1 \, d_1 \, w_2}{a_1 \, F_2^{\,2} \, \vartheta_1 \, \lambda_2 \, d_2 \, w_1} = 0.84;$$

or, allowing for the fact that in the former a portion of the beam is diaphragmed out, and that the collimator diaphragm is slightly smaller than the beam, the relative intensity should be about as 78[§] : 100. That is, assuming equal light

*The value given is the computed one, based upon Hartmann's coefficient of absorption for flint glass, No. 0.102; *i. e.*, 0.53 for a thickness of glass of 100 mm. [*Astroph. Jour.*, **11**, 410, 1900]. The corresponding figure for the Mills spectrograph, as determined experimentally [*Astroph. Jour.*, **8**, 137, 1898] is 25 per cent.

†Estimate based on values given in Vogel's table. *Astrophysical Journal*, **5**, 89, 1897. A slight allowance is made for the fact that each lens is triple.

‡*The Mills Spectrograph of the Lick Observatory*, by W. W. Campbell. *Astrophysical Journal*, **8**, 137, 1898.

§Accepting the reduction for diaphragming, and the 5 per cent and 12 per cent losses mentioned below for thicknesses of atmosphere and glass, respectively, the exposure times with the northern and southern installations should be as

$$0.78 \times 0.95 \times 0.88 : 1.00 = 65 : 100.$$

That is, the equivalent times for the spectrograms of *Mars* are 40 minutes and 61 minutes. The increase required, from 61 to 80 minutes, is 31 per cent; or, looking in the opposite direction, a decrease of 24 per cent in the actual exposure time, from 80 to 61 minutes, would correspond to equal efficiencies.—W. W. C.

efficiencies for the two instruments the exposures should be .78 as long with the Mount Hamilton apparatus as with that used in Chile. Since the actual ratio is about one half, the efficiency of the latter as compared with the former is as 50 to 78, or 64 per cent. The telescopes seem to be about equally efficient as light gatherers,* each delivering in the neighborhood of 50 per cent of the incident light, and, as the question of telescopic definition does not enter in the case of a planet, the falling off in efficiency of 36 per cent would appear to be due to increased absorption in the optical train of the Chilean spectrograph, and perhaps partly to the entirely external factor of increased atmospheric absorption at the Chilean station. On clear nights the stars appear to the eye to be quite as bright viewed from *Cerro San Cristóbal* as from Mount Hamilton, but on account of the lower altitude of the former place (2750 feet) light must travel through, on the average, an extra two thousand feet of air, and it is estimated that this causes a loss of 5 per cent of the photographic light. On account of extra thickness of the lenses and the arrangement of the prisms in the Chile spectrograph the light passes through an extra thickness of 1.95 cm. of glass, which should cause a loss of about 12 per cent. These two causes of loss would reduce the efficiency from 100 to 84 per cent, but they leave the difference between the latter figure and 64 per cent unaccounted for.†

* In the foregoing discussion a_2 represents the area of the mirror after deducting the area cut out by the secondary mirror. The quantity $R = 50$ per cent (see page 45) should therefore be taken as the light efficiency of the reflecting telescope.

† The subject of this paragraph,—the relatively long exposure times required in Chile,—should be given full consideration, both because it vitally concerns the efficiency and output of the expedition, and for its value to the many observers who will in the future employ reflecting telescopes in radial-velocity determinations. "The question of economizing light already collected is as important as that of providing larger object-glasses, and merits the fullest consideration." (*Astrophysical Journal*, **8**, 136, 1898.)

Mr. Wright's experience that the same ratio of exposure times holds for stars as for the extended areas of the planets and the Moon removes at once from the discussion any question of the telescopic definition or of the clock-following. If we grant that the refractor and the reflector deliver upon the slit-plates the same proportion (50 per cent, say) of the photographic rays incident upon the objectives, there can be no escaping the fact that the Chile spectrograph is more wasteful of light than the original Mills spectrograph, either through greater absorptions and reflections by its optical train, or because the effective slit-widths were not so great as they purported to be. The latter condition seems scarcely possible. If the southern prisms transmit 24 per cent less light than the northern ones, which corresponds approximately to a 6 per cent greater loss in the southern prism train [75 per cent loss and 25 per cent transmission north; 81 per cent loss and 19 per cent transmission south], the results would be explained. Allowance has already been made for the difference of path with reference to the vertices in the two sets of prisms, but not for the fact that the refracting angle of the southern prisms is 63° 28′ whereas that of the northern is but 60°. Assuming equal transparency this would explain a further reduction of 4 per cent in the incident light transmitted. The southern glass has the much lower index of refraction: 1.6744 for $H\gamma$, as against 1.7263 for the northern glass; and the lighter southern glass seemed to me perceptibly the clearer of the two.

I am strongly inclined to the view that the increase in exposure time was made necessary by low reflectivity of the silver-on-glass mirrors. Mr. Wright noted a relatively rapid decline of reflectivity with time, and concluded that the mirrors should be resilvered every two months. It is of course well known that there is a great difference in silver coats. To illustrate, Mr. Wright's measures of reflectivity described on page 45 gave 68 per cent with age of coat on large mirror 2 days and on small mirror 4½ months; and 73 per cent with age of coat on both mirrors 3½ months. It is possible that the silvering process employed gave too thin a coat, or that the coat would not stand as much burnishing as it should.

Dr. Curtis's first silvering of the mirror occurred in March, 1906, and his plans were formed with reference to securing a *thick coat.* His "first coat was very thick and hard, but blotched over one fourth of the mirror, due

Of the pieces of minor apparatus the measuring microscope is the one mentioned by Dr. Campbell in his description of the Mills spectrograph of the Lick Observatory. It was made by Toepfer of Potsdam. The induction coil for exciting the comparison spark was supplied by Queen and Company. The following values of the constants were furnished by the makers:

Capacity of primary condenser	2½ microfarads
Size of wire on primary coil	No. 12 B. & S. = .081 in. (single cotton)
Size of wire on secondary coil	No. 34 B. & S. = .0063 in. (single silk)
Number of turns on primary coil	125
Number of turns on secondary coil	12,000
Capacity of secondary condenser	.005 microfarads

A primary current of about five amperes is used.

THE DOME.—The dome was designed and built by Warner and Swasey, and is after their standard plans. Except in one or two minor details of construction, which are not of general interest, its operation is satisfactory. It is a steel framework, sheathed with wood. The sheathing is covered with heavily painted canvas, which does not, however, render the dome water-tight. The canvas will soon be replaced by galvanized iron.*

The observations secured by the expedition appear to be of the same order of accuracy as those made at Mount Hamilton with the Mills spectrograph. The following table contains a list of the check observations of the Moon, *Venus* and *Mars* which have been measured up to date. The list does not include observations made using λ 4450 as the central ray:

doubtless to having left the solution on too long." The second trial, a day or two later, "gave a beautiful coat. The secondary was silvered also." Good stellar spectrograms were then obtained with exposures at least 40 per cent shorter than those given to spectrograms of the same stars with the silver coats of preceding years; the conditions of slit-width, atmosphere and altitude being substantially equal. The same reduction of exposure time was obtained also for lunar spectrograms. Taking account of the constants of the two installations, the efficiency of the southern apparatus certainly equaled and probably surpassed that of the 36-inch refractor and Mills spectrograph. This high reflectivity appeared to decrease very slowly in succeeding months, but full information is not at hand, as Dr. Curtis, who was alone for six months, devoted his attention to making improvements in and additions to the equipment of the station, and regular observing was not undertaken. Moon spectrograms obtained when the silver coats were 2½ months old showed that the reflectivity had diminished but little. With age of coats 7 months, at the end of the rainy season, the silver was in poor condition, giving a reflectivity of only 63 per cent.

The mirrors were resilvered in October (1906). "On the first day the coats looked like good ones; they are thick, but have deteriorated rapidly." The reflectivity at age 8 days was 77 per cent. The coats failed rapidly, and in a month "we are back at the old scale of exposure times, or worse." This may or may not have been due to the artificial refrigeration to which the large mirror was subjected during the period, to keep its day temperature down to that of night. Dr. Curtis has been unable to obtain certain purified chemicals since the Chilean earthquake, and he thinks this may possibly account for his failure to equal his first coat.

It is evident that the subject of silvering merits most careful attention. Considerable experimental work would no doubt be a profitable expenditure of time and money.—W. W. C.

* It was replaced by galvanized iron early in 1906.—W. W. C.

Object.	Date.	Velocity. Observed.	Velocity. Computed.	Residuals. O - C	Photographed by	Measured by
Venus . . .	1903, Nov. 22	+ 13.32 km.	+ 12.53 km.	+ 0.79 km.	Wright	Wright
Venus . . .	1904, Jan. 5	+ 12.06	+ 12.13	- 0.07	Wright	Palmer
Venus . . .	March 14	+ 9.75	+ 9.57	+ 0.18	Wright	Palmer
Moon . . .	May 29	- 0.23	+ 0.15	- 0.38	Wright	Wright
Mars . . .	1905, Jan. 31	- 18.57	- 18.97	+ 0.40	Wright	Palmer
Mars . . .	March 11	- 17.07	- 17.21	+ 0.14	Wright	Palmer
Mars . . .	March 29	- 14.60	- 15.14	+ 0.54	Wright	Wright
Mars . . .	June 21	+ 6.16	+ 5.86	+ 0.30	Palmer	Palmer
Mars . . .	August 24	+ 8.48	+ 8.48	0.00	Wright	Wright
		Mean residual, ...		+ 0.21		

It is impossible for the present to say whether the slight tendency of the residuals in the positive direction indicates a systematic error in the plates secured with the spectrograph.

The following record of our observations* of a few stars will serve to show the accordance of the results:

α *Centauri*, $\alpha = 14^h\ 32^m.8$, $\delta = -60°\ 25'$.

Date.	Fainter Component. Velocity.	Brighter Component. Velocity.	Measured by.
Type of spectrum,	K 5 M	G	
1904, Feb. 21 . . .	. . .	- 24.0 km.	Wright
Feb. 25 . . .	- 18.9 km.	. . .	Wright
March 4 . . .	- 18.7	- 24.2	Wright
June 23 . . .	- 19.7	- 24.6	Wright
1905, Jan. 27 . . .	- 19.3	- 24.8	Wright
March 7 . . .	- 20.0	- 24.6	Wright
April 17 . . .	- 18.8	- 24.7	Wright

α *Carinæ*, $\alpha = 6^h\ 21^m.8$, $\delta = -52°\ 39'$.

Type of spectrum, K. Photographic magnitude, about — 0.5.

1903, Sept. 21	+ 20.7	R. H. Curtiss
1904, Jan. 19	+ 21.0	Palmer
Sept. 6	+ 20.1	Albrecht
Sept. 11	+ 20.0	Palmer
1905, Jan. 6	+ 20.4	Palmer
Jan. 6	+ 20.7	Palmer
Jan. 6†	+ 20.7	Albrecht
Jan. 6	+ 20.3	Albrecht
Jan. 6	+ 20.4	Palmer
Nov. 9	+ 20.2	Albrecht
Nov. 24	+ 20.7	Palmer

g Carinæ, $\alpha = 9^h\ 13^m.4$, $\delta = -57°\ 7'$.

Type of spectrum, *Ma*. Photographic magnitude, about 5.5.

1903, Dec. 20	- 3.8	Palmer
1905, Jan. 19	- 4.9	Palmer
March 10	- 4.5	Palmer
May 25	- 3.6	Wright
1906, Feb. 2	- 4.8	Wright

*These observations were inserted after my return from Chile.—W. H. W.

†Independent measurement of the same plate by Dr. Albrecht.

A chart of the stars on our observing list is shown in Fig. 13. This chart is so platted that areas on the chart are proportional to the corresponding areas on celestial sphere. The relative star density of any two parts of the sky is therefore shown truly by the chart.

A brief comparison of the relative efficiencies of refracting and reflecting telescopes for the determination of stellar velocities in the line of sight, based on

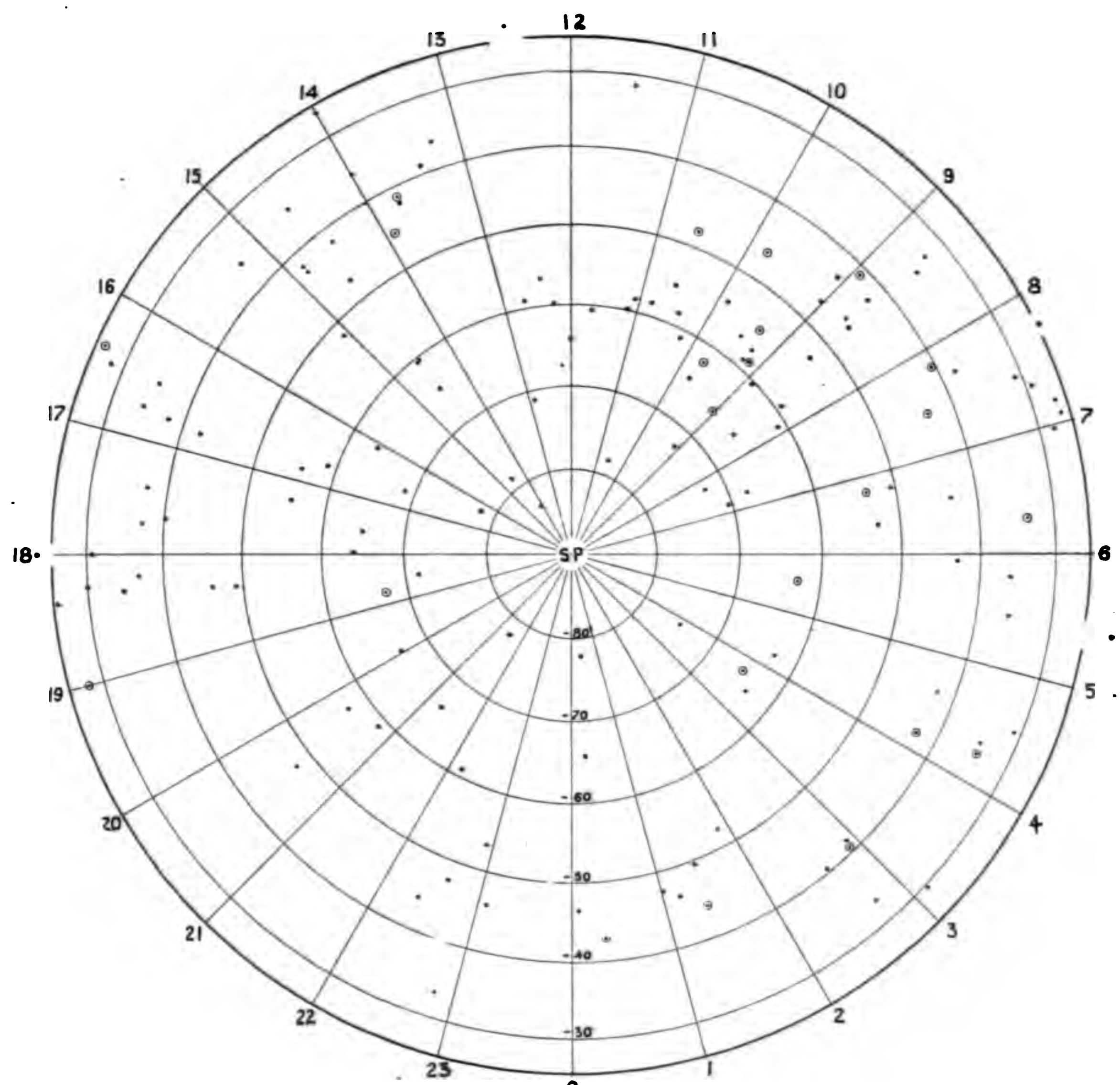

FIG. 13. Chart showing the distribution of stars observed by the Mills Expedition. The method of projection is such that equal areas on the chart represent equal areas in the sky. Encircled stars have variable radial velocities.

experience with the 36-inch refractor of the Lick Observatory and the instrument under discussion may not be out of place. An absolutely rigorous comparison of these two instruments can not of course be made without first using each in connection with the same spectrograph for the purpose of equalizing external conditions, but our experience leaves us with a strong preference for the refractor.

The point most in favor of the reflector is its low cost.* The question of *perfect* achromatism is not one of prime importance for work of this character, since the range of spectrum which can be utilized is comparatively small and should be well covered by a photographically corrected refractor. The disadvantages of the reflector are general, and include its susceptibility to disturbance by varying temperature, the need of frequent resilvering to maintain the greatest perfection of polish, and the liability of the coat of silver to deteriorate during damp weather. There are many clear damp nights which would be available, partially at least for work with a refractor, on which a mirror can not be exposed without serious risk of injury to the silver. At the Chilean station such nights form a considerable percentage of the clear ones during the rainy season, when observing weather has its greatest value. With clear weather and good seeing a refractor is practically always at its best, and only temporary inconvenience results from an occasional dewing of the objective. As to the relative rapidity of the two telescopes for this kind of work it is impossible to give a definite opinion without trying each in connection with the same spectrograph, though the facts which we have referred to would seem to indicate that the two are about equal in the region of spectrum used, *i. e.*, the $H\gamma$ region.

The foregoing observations on the relative efficiencies of the two classes of instruments apply only to their availability for velocity determinations with high dispersion spectrographs. For general spectroscopic work the reflector has well known and important advantages, and is without doubt the superior instrument.

The inconveniences attendant upon the use of the reflector could be lessened to a great degree by providing proper facilities for the resilvering of the objective. If the silver is to be replaced five or six times a year, it is imperative that the operation should be made both safe and rapid. A silvering room or laboratory, capable of being heated if necessary, should be available close to the dome, and means should be at hand for removing the mirror in some safe and easy manner and transporting it to this room. The necessity for a silvering laboratory is felt chiefly when the temperature is too low for the proper action of the solutions, but in any case it would be of the greatest convenience. In appointing the laboratory, arrangements should be made for washing the mirror after silvering. The floor should be of some waterproof material so laid as to allow a ready run off for the considerable amount of wash water, etc., which it is necessary to use.

The photographic views of *Cerro San Cristóbal* and of the Observatory are from negatives made by Professor Ernesto Greve. The remaining photographs were made by Dr. Harold K. Palmer of the Mills Expedition.

Santiago, *Chile*,
October, 1905.

*This, it should be stated, is a most important consideration. The relative cost of the Mount Hamilton refractor and the Mills telescope was about as eighteen to one. Practically the same ratio holds for the dome and accessories.

SUPPLEMENTARY NOTES.

A. ON THE COLLIMATION OF A REFLECTING TELESCOPE.

In collimating a reflecting telescope the usual practice of observers appears to be to locate a point in the focal plane directly opposite the center of the mirror. If the mirror has been perfectly ground the center of the mirror will be the vertex of the parabola, and the adjustment made as indicated will be correct. We have records, however, of mirrors whose definition has been improved by tilting them with reference to the central ray.* In other words the vertex of the best parabola that can be accommodated to the surface of such mirrors is displaced from the center of the disk. There seems to be no good reason why a mirror should not be *squared on* by tests on the image of a star, just as a lens objective is adjusted. The tests can easily be made with either a knife edge or an eyepiece. Assume that there is a displacement of the vertex of the parabola V from the center O, and for simplicity let this displacement be to the observer's right. Determine by reflection the line normal to the center of the mirror and examine the star image formed on this line as axis. It will be astigmatic in a right and left direction, light being thrown to the left end of the image from the right and left segments of the mirror and to the right end from the central regions. The expression for the amount of this aberration, that is for the angle subtended by the elongated image at the center of the mirror, is

$$\tan \gamma = \frac{3}{8} \frac{R^2 \; VO}{F^3} \dagger$$

The character of the aberration is easily recognized by the knife-edge test, or with an eyepiece by blocking out an area at the center of the mirror and examining the out-of-focus beam. In the latter case the dark center due to the diaphragm will be shifted to one side of the center of the beam. In this way it was found that the vertex of our mirror is displaced by an amount less than an inch from the center of the hole in the glass, the point upon which we were accustomed to collimate. For a mirror of the diameter and focal length of the Mills reflector a shift of one inch (2.5 cm.) would introduce an aberration of 2.8 seconds of arc.

*See Dr. Draper *On the Construction of a Silvered Glass Telescope. Smithsonian Contributions to Knowledge*, Volume XIV or XXXIV, p. 9.

†This formula is adapted from the work of Poor, *Astrophysical Journal*, 7, 120, 1898. Substituting for α in his formula the angle subtended by OV at the *center of curvature* of the mirror and making one or two obvious alterations, the expression here given results.

B. EFFECT ON THE IMAGE OF A RELATIVE DISPLACEMENT ALONG THE AXIS OF COLLIMATION OF THE FOCI OF THE PARABOLIC AND HYPERBOLIC MIRRORS OF A CASSEGRAIN SYSTEM.

In Figure 14 let CD represent the hyperbolic mirror, T and A being the foci. If the adjustment of the mirrors is perfect the rays of the parabolic mirror converge toward the point T and are reflected to A. If, however, the focus of the parabola be moved to T', the reflected rays will converge upon a region in the vicinity of A'. Let the ray BC, directed toward T, strike the mirror at C and be reflected to A while $B'C$ directed toward T' is reflected to A' on the axis of the hyperbola. From C drop CO perpendicular to AT and let $OC = y$. Then from the figure,

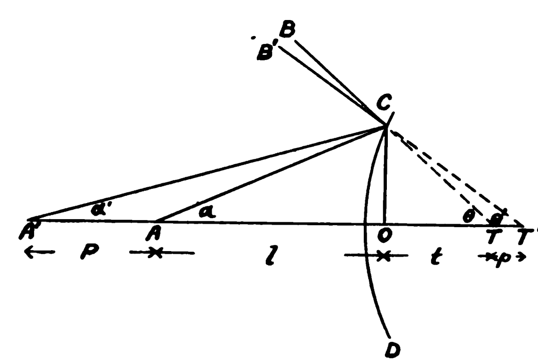

FIG. 14.

$$\alpha - \alpha' = \theta - \theta' ,$$

$$\therefore \quad \tan (\alpha - \alpha') = \tan (\theta - \theta'), \tag{1}$$

$$\tan \alpha = \frac{y}{l} , \qquad \tan \alpha' = \frac{y}{l + P} , \tag{2}$$

$$\tan \theta = \frac{y}{t} , \qquad \tan \theta' = \frac{y}{t + p} . \tag{3}$$

Substituting (2) and (3) in (1) we have, after simplifying,

$$P = p \, \frac{l^2 + y^2}{t^2 + y^2 + (t - l) \, p}$$

If the equation of the hyperbola be

$$\frac{x^2}{a^2} + \frac{y^2}{a^2 (1 - e^2)} = 1 ,$$

then $\qquad t = ae - x , \qquad l = ae + x ,$

and
$$P = \frac{(ae + x)^2 + y^2}{(ae - x)^2 + y^2 - 2 p x} , \tag{4}$$

where y is the distance from the axis to the point C; and

$$x = a \sqrt{1 - \frac{y^2}{a^2 (1 - e^2)}}$$

If f_1 and f_2 be the distances from the vertex of the hyperbola to the foci T and A we have,

$$\frac{f_2 - f_1}{2} = a\,, \qquad \frac{f_2 + f_1}{f_2 - f_1} = e\,.$$

By the aid of these relations, (4) reduces to the following approximate expression, which is sufficiently exact for all ordinary cases:

$$P = p\,\frac{(f_2 + u)^2 + y^2}{(f_1 - u)^2 + y^2 - 2p\,(a + u)}$$

where

$$u = \frac{f_2 - f_1}{4 f_1 f_2}\,y^2\,.$$

If P_0 is the value of P corresponding to $y = 0$, then

$$P_0 = \frac{f_2^2}{f_1^2 - 2pa}\,,$$

The quantity $P - P_0$ is the difference between the focal length of a zone of the hyperbolic mirror of radius y and the focal length of the center of the mirror.

The following values have been computed using the constants of the Mills telescope, *i. e.*, $f_2 = 174$ inches, $f_1 = 55$ inches, $y = 4\frac{3}{4}$ inches.

p	P_0	$P - P_0$
1 inch	10.42 inches	—.036 inches
2 inches	21.73 "	—.080 "
3 "	34.04 "	—.131 "
6 "	78.60 "	—.354 "

It would appear that a range of focus of a foot or more on either side of the theoretical focal point could be secured, without seriously injuring the definition of the telescope, by moving the secondary mirror back and forth along the axis of collimation.

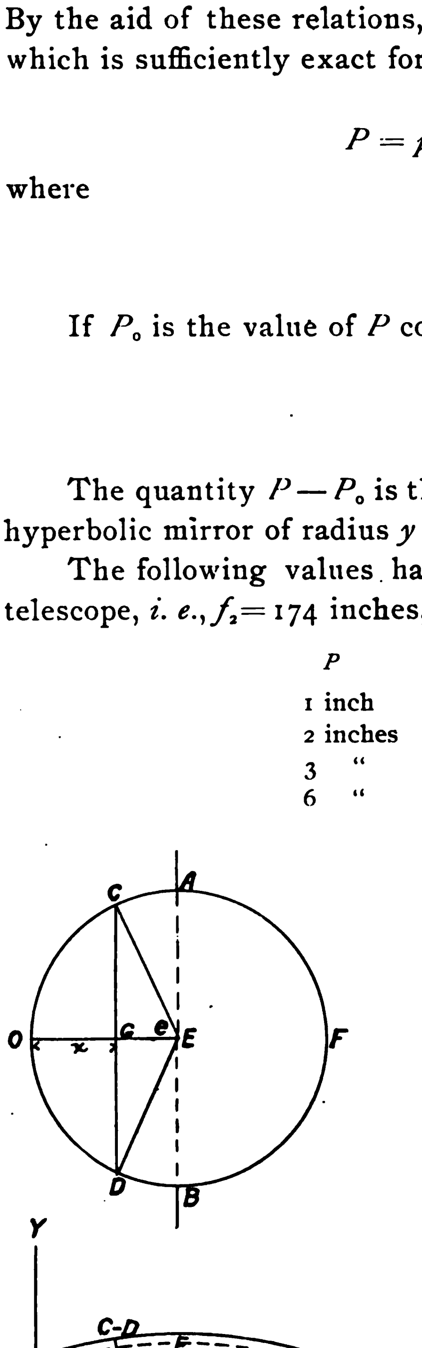

FIG. 15.

C. FLEXURE IN A MIRROR RESTING HORIZONTALLY ON ONE OF ITS DIAMETERS.

In Fig. 15 let OF be a circular disk of glass of radius R, thickness T, and weight P. Suppose the disk to be balanced on the diameter AB and in the lower sectional view let OEF be the neutral axis. This axis lies midway between the two surfaces of the disk. It is desired to determine the angular deflection at the point O, or what is the same thing, the slope of the neutral axis at this point.

Take O as the origin of coördinates, OX and OY being drawn as indicated in the figure. Let CD be the section cut by a plane perpendicular to the disk and parallel to the line AB. This plane cuts the line OE at G. Let $OG = x$ and designate the angle CEO by Θ.

Further, let

E = Young's modulus of elasticity for the glass composing the disk,
I = the so-called "moment of inertia" of the section CD about its longitudinal axis; that is, the moment of inertia with the mass factor left out,
A = the area and W the weight of the segment COD,
M = the weight moment of this segment about the longitudinal axis of CD,
w = the weight per unit of surface of the mirror,
u = the distance from G to the center of gravity of the segment COD,
$\bar{r}$ = the distance from E to this center of gravity.

The following relations may be shown to hold:

$$E I \frac{d^2 y}{d x^2} = M ,^* \qquad (1)$$

$$M = -u W ,$$

$$u = \bar{r} - R \cos \theta ,$$

$$\bar{r} = \frac{2 R^3 \sin^3 \theta}{3 A} ,$$

$$A = R^2 (\theta - \sin \theta \cos \theta),$$

$$w = \frac{P}{\pi R^2} ,$$

$$W = A w ,$$

$$I = \frac{R \sin \theta \, T^3}{6} .$$

Substituting in (1) by means of the equations which follow it we have:

$$\frac{d^2 y}{dx^2} = - \frac{w}{E T^3} \left\{ 4 R^2 \sin^2 \theta - 6 R^2 \csc \theta \cos \theta (\theta - \sin \theta \cos \theta) \right\} .$$

This expression is more easily integrated with regard to θ than x. We have, therefore, on making the substitution,

$$dx = R \sin \theta \, d \theta ,$$

$$\frac{d^2 y}{dx \, d\theta} = - \frac{w}{E T^3} \left\{ 4 R^3 \sin^3 \theta - 6 R^3 \cos \theta (\theta - \sin \theta \cos \theta) \right\} ;$$

* This equation is the ordinary one used by engineers for computing flexure in beams. Its development may be found in such works as Du Bois, *The Strains in Framed Structures*. As regards sign, the clockwise moment is considered positive.

or, integrating once and evaluating the constant,

$$\frac{dy}{dx} = -\frac{w}{E\,T^3}\left\{ -\frac{4}{3} R^3 \cos\theta\,(\sin^2\theta + 2) - 6\,R^3\left(\cos\theta + \theta\sin\theta + \frac{\cos^3\theta}{3}\right) + 3\,R^3\pi \right\}.$$

This relation gives the slope of the disk for any value of θ. Substituting $\theta = 0$ we have for the slope at O

$$\left(\frac{dy}{dx}\right)_{\theta=0} = \left(\frac{32 - 9\pi}{3\pi}\right)\frac{P\,R}{E\,T^3}$$

$$= .395\,\frac{P\,R}{E\,T^3}$$

Substituting the constants of our mirror

$P = 557$ lbs.,
$R = 18$ inches,
$T = 6$ inches,
$E = 10{,}000{,}000$ pounds per square inch (assumed),

and designating the angle of deflection at O by δ, we have

$$\delta = 0''.38.$$

D. FLEXURE OF A MIRROR RESTING VERTICALLY ON ITS EDGE.

In Fig. 16 let $EABD$ represent the normal shape of the mirror, f the focus, and F the focal length. The shape the mirror will assume when acted upon

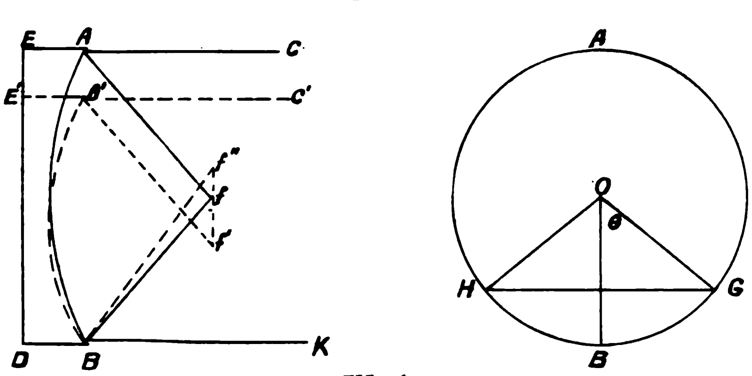

FIG. 16.

by the force of gravity may be indicated by $E'A'BD$. Let CA and KB be incident rays parallel to the axis, for no flexure, and let $C'A'$ be the ray corresponding to CA, when the mirror is distorted. Since there is no weight bearing on the top of the mirror the angle between the surface of the mirror and the incident ray will be the same for both A and A'. The reflected ray from the latter point will therefore strike the focal plane at a point f' distant $ff' = AA'$ from f. The surface at B on the other hand, on account of the vertical compression of the glass at this point, will assume a greater angle with the vertical, and the ray reflected from the distorted surface will intersect the focal plane at f''. The total

aberration introduced will be the angle subtended at the center of the mirror by the line ff''. To determine the amount of the settling AA', it will be assumed that the compression at all points of a horizontal line HG is the same. This will be practically true except in the immediate vicinity of B, and the condition is sufficiently well realized to be assumed for present purposes. Furthermore, for simplicity, suppose T, the thickness of the mirror, to be uniform throughout. The compression produced in a thin element cut out by the plane HG and one parallel to it and distant Δh may be shown to be

$$\Delta C = \frac{W \Delta h}{E a}$$

where W is the weight of the segment HAG,

E is Young's modulus of elasticity,

a is the area of the section cut by HG.

If P be the weight of the mirror, then

$$W = \frac{\pi - \theta + \sin\theta\cos\theta}{\pi} P,$$

$$\Delta h = R \sin\theta \, \Delta\theta,$$

$$a = 2\, TR \sin\theta,$$

$$\therefore \Delta C = \frac{(\pi - \theta + \sin\theta\cos\theta)\, P}{2\, \pi . E\, T} \Delta\theta;$$

or, assuming the differential relation and integrating,

$$C = AA' = ff' = \frac{P}{2\,\pi\, E\, T}\left(\pi\theta - \frac{\theta^2}{2} + \frac{\sin^2\theta}{2}\right)_{\theta=0}^{\theta=\pi}$$

$$= \frac{\pi P}{4\, E\, T}$$

In determining the deflection of the tangent to the surface at B it will be assumed that the mirror rests on an arc of length L. Let $\Delta\alpha$ be the deflection, then

$$\Delta\alpha = \frac{P \sin\varphi}{2\, E\, T\, L}$$

where φ is the semiangular aperture of the mirror at the focus. The deflection of the reflected rays is therefore

$$2\, \Delta\alpha = \frac{P\sin\varphi}{E\, T\, L},$$

and

$$ff'' = \frac{P \tan\varphi}{E\, T\, L \cos^2\phi} F,$$

where F is the focal length of the mirror. The total aberration γ due to the flexure of the mirror while resting on its edge is

$$\gamma'' = \frac{f'f + ff''}{F \sin 1''} = \frac{P}{E\,T \sin 1''}\left(\frac{\pi}{4\,F} + \frac{\tan\varphi}{L\cos^2\frac{\phi}{2}}\right).$$

Substituting the dimensions of the Mills mirror and assuming $L = 6$ inches, we have

$$\gamma = 0''.0345$$

a negligible quantity; the more so when we consider that most of it is due to the area in the immediate vicinity of the support at B.

Mount Hamilton,
March, 1907.

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1907-1911

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D. O. MILLS EXPEDITION

CERRO SAN CRISTÓBAL, SANTIAGO, CHILE

FROM ITS ORGANIZATION IN

DECEMBER 1900 TO MARCH 1906

PREFACE

The events leading to the inception and organization of the D. O. Mills Expedition to the Southern Hemisphere are described in Part 1 of this volume. A general description of the observing station on Cerro San Cristóbal, in the northeastern suburbs of Santiago, Chile, is contained in Part 2. The instrumental equipment and the observing methods employed are described in Part 3. The detailed results secured during the first period of the expedition, up to March 1, 1906, are published in Part 4.

Parts 1, 2 and 3 were published by the State Printing Office, Sacramento, W. W. Shannon, Superintendent, in the year 1907, and promptly distributed to the correspondents of the Lick Observatory. Acknowledgments are due to the officials of the State Printing Office for great care exercised in meeting the requirements.

The results contained in Part 4 were ready for publication on July 1, 1908, but no funds were available for this purpose. It was hoped that funds would be available in July, 1909, but in this we were disappointed. When this regrettable delay was brought to the attention of Mrs. Phoebe A. Hearst, Regent of the University of California, she made private provision with exceeding generosity to enable the printing of Part 4 to proceed. The printing was done at the University Press, Berkeley, and acknowledgements are due to Mr. A. H. Allen, Manager, for his kind offices. The limited facilities of the University Printing Office have made the processes of publication unavoidably slow, but it is a pleasure also to acknowledge the constant personal interest and attention of Mr. J. W. Flinn, Superintendent of the Printing Office.

W. W. Campbell.

CONTENTS

ERRATA LICK OBSERVATORY, VOLUME IX, PARTS I, II AND III.

Page 16, line 38, for Henry M. Wilson read Henry L. Wilson.

Page 22, line 9, for Henry M. Wilson read Henry L. Wilson.

Page 22, line 25, for Iquiqui read Iquique.

Page 65, line 26, for $P = \frac{(ae+x)^2+y^2}{(ae-x)^2+y^2-2px}$ read $P = p\frac{(ae+x)^2+y^2}{(ae-x)^2+y^2-2px}$.

Page 66, line 11, for $P_0 = \frac{f_2^2}{f_1^2-2pa}$ read $P_0 = p\frac{f_2^2}{f_1^2-2pa}$.

Page 66, line 16, head of first column, for P read p.

Page 69, bottom, for $\cos^2 \frac{\phi}{}$ read $\cos^2 \frac{\phi}{2}$.

PART IV

RADIAL VELOCITIES OF 150 STARS SOUTH OF DECLINATION $-20°$

DETERMINED BY THE

D. O. MILLS EXPEDITION

PERIOD 1903–1906

DISCUSSED BY

W. H. WRIGHT

WITH THE ASSISTANCE OF

H. K. PALMER AND S. ALBRECHT

UNDER THE DIRECTION OF

W. W. CAMPBELL

UNIVERSITY OF CALIFORNIA PUBLICATIONS.

PUBLICATIONS OF THE LICK OBSERVATORY, VOL. IX, PART 4.

DETERMINATION OF STELLAR RADIAL VELOCITIES

THE OBSERVING LIST

In planning the D. O. Mills Expedition, Director Campbell had in mind the observation of between 150 and 175 stars, south of declination —30°, with the 3-prism spectrograph. Each star was to be observed four times, while any whose velocity was found to be variable was to be more fully investigated. Dr. Campbell's instructions were to "begin work on the brighter stars whose spectra contain sharp lines; but take one photograph each of all bright stars, to test for measurable lines, rejecting those with lines hopelessly broad." The observing list was made out by the writer acting under these general instructions.

If a list were made up of all stars brighter than any given visual magnitude, say the fifth, it would contain a large majority of first type stars, whose radial velocities could not be determined with the degree of accuracy which we have come to associate in our minds with work of this character. From the point of view of the student of certain statistical problems it might appear advantageous to use such a list, and it must be admitted that among the most important uses to which data of the character of those secured by the expedition can be put are those associated with the solution of such problems; but even here the selection of the visual, in preference to the photographic magnitude or magnitude corresponding to any other part of the spectrum, as a basis for compiling the list is quite an arbitrary matter. Furthermore the broad-line stars can be handled quite as effectively from the standpoint of accuracy, and much more efficiently from that of time, with spectrographs of lower dispersion than that provided for the expedition during the first three years of its existence. On the other hand there are certain investigations which require measurements of the very highest accuracy, and the scope of a catalogue of radial velocities with reference to these is greatly broadened by the inclusion of as many stars as possible whose velocities can be accurately determined. It was therefore considered desirable to have the list include as many stars as possible of this character.

A very good aid in the formulation of a provisional working list is furnished by Professor E. C. Pickering's classification of stars according to a series of magnitudes depending on the intensity of a star's spectrum near the G line, this being the part of the spectrum used in the observations. Most of the brighter northern stars have been classified according to this system, but unfortunately for the purposes of our expedition the southern stars had not been similarly treated, though the brighter of these had been classified by Miss Cannon according to spectral type. In order to bridge the difficulty the mean difference between the magnitude representing the spectral brightness at the G line, as given in the Draper Catalogue, which, for brevity, will be called the photographic magnitude, and the visual magnitude, was taken for each of a number of northern stars of the various spectral classes. These differences were then applied as corrections to the visual magnitudes of the southern stars of the corresponding classes to get their approximate photographic magnitudes. This method is not very satisfactory, as the difference between the two magnitudes varies considerably even among stars of the same class, but it served

fairly well, in the absence of accurate data, as a guide in making up a provisional observing list.

Speaking generally, spectra of the second and third types contain numerous lines which can be accurately measured, while in the first type stars the lines are few and hazy. It was therefore proposed to observe once:

1. All stars brighter than 5½ photographic magnitude having spectra of the second and third types and the more advanced first types, and

2. All stars brighter than 4th visual magnitude whose spectra belong to the earlier first type.

Following out this general plan the spectra of about 250 stars were photographed during the course of the work of the expedition, and of these 150 were retained on the final working list.

Measurement and Reduction of Spectra.

A general account of the instruments and the methods of observation used by the expedition is given in Part III of this volume, and there is no occasion to add to what has been said on these subjects. Some words of explanation are required, however, concerning the methods of reducing the plates.

As stated on page 56, the plates were secured with the spectrograph arranged in three different manners. These may be referred to briefly as

(*a*) λ4340.6 (Hγ) central in field $\begin{cases} (1) \text{ long camera.} \\ (2) \text{ short camera.} \end{cases}$

(*b*) λ4450 central in field—long camera.

A great majority of the plates were secured under the system (*a* 1); that is, using the long camera and the Hγ ray central in the field. Out of 899 exposures, 674 were made with this arrangement of the spectrograph, while 127 come under division (*a* 2). That is, 801 or 89 per cent. of all the exposures were made with the Hγ ray central. There are 98 plates which fall under the head (*b*).

A satisfactory degree of accuracy is believed to have been obtained in all the (*a*) observations. The (*b*) observations are not regarded with the same confidence for a number of reasons. Some of these are referred to on page 56. Another is that the wave-lengths of the lines of titanium, which was used in this case for the comparison element, do not appear to have been determined as accurately as those of the iron lines which serve as reference lines on the (*a*) plates. Furthermore the number of observations is comparatively small, and the series therefore does not inspire the same confidence that comes from a large number of uniformly consistent results. It is believed, nevertheless, that these observations furnish data too valuable to discard, and the (*b*) results have been incorporated with the others, with an assigned weight of ½.

Reduction of Plates having the Hγ Ray Central.—In reducing the measurements of the (*a*) plates a uniform system has been followed. Standard dispersion tables similar to those described by Dr. Campbell (*Astrophysical Journal*, **8**, 144, 1898, Table II) were constructed, giving the readings of the screw of the measuring microscope corresponding to the wave-lengths of various stellar lines. The method of computing these tables was slightly modified from that adopted by Dr. Campbell and these modifications will be referred to here for the sake of completeness. The computations were made by the Hartmann-Cornu formula, and the computed results were corrected by means of a secondary curve based on the residuals, observed — computed, of all the lines measured on the standard plate. For a full account of the use of such a table in reducing the measurements of stellar spectrograms the reader is referred to Dr. Campbell's article.

The method of reduction here referred to is much more convenient than that which requires the computation of a new curve for every plate that is reduced, and even a limited experience in the use of it will convince the observer that it leaves nothing to be desired in the matter of accuracy. The chief objection which can be urged, *a priori*, against the use of a table based on a single plate would appear to be the fact that this plate and the plate to be measured are taken

under different conditions. As a matter of fact experience shows that a variation in conditions of observation makes little difference except in the scale of the spectrogram, and all possible differences are taken up by the secondary curve based on the residuals of the comparison lines on the measured plate. To illustrate the range of conditions under which such a table will serve, it may be stated that the tables constructed for the Chilean spectrograph may be used, in an emergency, for reducing plates taken with the Mills spectrograph at Mt. Hamilton, an instrument of different dimensions, and carrying prisms of a different quality of glass, by simply multiplying the tabular values by a constant coefficient. If a table will hold good under such a range of conditions, it may be considered safe to use it in the restricted variation involved in the use of a single instrument.

Assumed Values of the Wave-lengths.—With a few exceptions the wave-lengths used in the present investigation are based on Rowland's *Preliminary Table of Solar Spectrum Wave-lengths.* For convenience in discussion, the lines used will be grouped under two heads: comparison lines and stellar lines. It should be remembered that the discussion immediately in hand refers to the reduction of plates taken with λ4340.6 ($H\gamma$) as the central ray.[1]

Comparison Lines (Iron).—It has been known for some time that a number of the iron wave-lengths assigned by Rowland in the table quoted above are seriously in error.[2] The character of the errors is such that a smooth curve can not be drawn, or expressed in a formula, which accurately expresses a relation between the values given by Rowland and the micrometer readings on the lines in the spectrum of iron. This matter has been discussed at length by Kayser, Hartmann,[3] and others. Many of the lines have been corrected by Kayser, by a method of *smoothing out* by which the general system of wave-lengths was unaltered. A similar plan of correction was adopted by Dr. Palmer during the course of his measurements of some of the spectra secured by the expedition. Dr. Palmer's results have been used in most of the reductions included in this volume. The effect of the change in the system is however inappreciable as each velocity depends upon the measurement of many comparison lines. It has therefore not been considered necessary to re-reduce a number of the earlier measurements which had been reduced by Rowland's wave-lengths before these corrections were determined. Dr. Palmer's wave-lengths are as follows:

λ	λ	λ
4236.101	4315.258	4427.482
38.980	25.941	42.510
47.591	37.223	47.889
50.293	52.910	66.721
50.942	69.945	76.182
60.639	76.101	82.390
82.570	83.722	94.730
94.291	4404.925	4528.798
4308.079	15.301	

Wave-lengths of Stellar Lines.—A limited experience in measuring stellar spectra will serve to show that, in many stars, certain lines have systematic displacements from the positions assigned them in Rowland's *Preliminary Table of Solar Spectrum Wave-lengths.* These displacements are, at their greatest, much larger than the displacements referred to in the remarks on comparison lines and they are usually considered to be due to the blending of the stellar lines with some of their neighbors.[4] In a limited number of cases, particularly where the correction is large, the stellar line probably has an entirely independent origin. The effect of these displacements is of course to give systematic residuals for these lines in the velocity determinations. A study of these residuals from the mean value of the velocity of each plate was undertaken by

[1] Page 74.
[2] Kayser, *Annalen der Physik*, (4), **3**, 1900; also *Astrophysical Journal*, **13**, 329, 1901.
[3] *Astrophysical Journal*, **18**, 167, 1903.
[4] See Albrecht, *Lick Observatory Bulletin*, **4**, 90, 1906; also *Astrophysical Journal*, **24**, 333, 1906.

Dr. Palmer, who from a discussion of 25 spectrograms determined a number of corrections to be applied to Rowland's wave-lengths. These corrections, as modified by the experience of Dr. Albrecht and the writer, are given in the following table, and the corrected values in column 3 have been used in reducing the observations incorporated in this volume. More recently Dr. Albrecht has investigated the matter of these residuals in greater detail, and his results, some of which have been used in the present investigation, will be published later.

Rowland	$\Delta\lambda$	Mills	
4246.996	—.028	4246.968	
50.945	+.017	50.962	In classes F, F8G use Rowland value
65.418	—.044	65.374	In classes G to M
	—.098	.320	In classes M_a and M_b
68.915	—.049	68.866	In classes G to M_b
74.911[5]	+.024	74.935	
87.566	+.039	87.605	
88.038	+.045	88.083	
4303.337	+.106	4303.443	In class F5G Pec.
13.797	—.026	13.771	
18.817	+.050	18.867	
25.152	+.043	25.195	
25.939	+.038	25.978	In classes G to M_b. In classes F, F5G use Rowland value
28.080	+.021	28.101	
31.811	—.016	31.795	
32.988	—.067	32.921	In classes G to M_b
47.403	+.061	47.464	In classes G5K to M_b
49.107	+.043	49.150	
52.908	+.041	52.949	In classes F5G to G5K
	+.064	.972	In class K
	+.082	.990	In classes K2M and K5M
	+.100	53.008	In classes M_a and M_b
55.257	+.037	55.294	
69.568	+.083	69.651	
69.941	—.017	69.924	
71.442	—.079	71.363	
75.103	+.016	75.119	
88.571	+.058	88.629	
90.149	—.031	90.118	In classes F to K
	—.006	.143	In classes K2M and K5M
	+.019	.168	In classes M_a and M_b
95.286[5]	—.044	95.242	In classes A5F to F8G
	—.016	.270	In classes G to K
	+.013	.298	In classes K2M to M_b
99.935	—.028	99.907	In classes F to K. Omit in classes K2M to M
4407.871	—.021	4407.850	
17.884	—.027	17.857	
18.499	+.043	18.542	
33.390	+.024	33.414	
35.851	—.034	35.817	
41.881	—.020	41.861	
47.892	+.023	47.915	
59.260[5]	+.064	59.324	In classes F to F8G
66.727	+.062	66.789	In classes K to M. In classes F to G use Rowland value
68.663	—.040	68.623	In classes A5F to F
	—.016	.647	In classes F5G to G
	+.010	.673	In classes G5K to K
	+.082	.745	In classes K2M to M
	+.161	.824	In class F5G Pec.
82.390[5]	—.014	82.376	

[5] These wave-lengths result from blending two close lines in Rowland's table according to the intensities assigned by Rowland.

On account of the method of derivation of these corrections, the effect of using the new wave-lengths should be to leave unchanged a velocity based on the original Rowland values, provided the determination depended on a sufficient number of lines. It sometimes happens, however, that in spectrograms of inferior quality only a few lines are available for measurement, and it was hoped that in such cases the wave-lengths given in the above table would give more reliable results than the original values. As a matter of fact the adoption of these corrections to the wave-lengths has had an almost inappreciable effect on the velocity determinations, and though it has served in many cases to reduce the residuals of individual lines from the mean value of the plate, it does not appear to have improved the residuals of the different plates from the mean of all the plates of a star. An obvious objection is that it introduces a new system of wave-lengths, which is liable to lead to some confusion on the part of the hurried reader. On the whole the writer regards as open the question as to whether the adoption of such a system is advisable, since the results can be published in such a form as to allow a ready correction of the velocity corresponding to any change in the wave-lengths which a future investigator might desire to make. A small table of coefficients designed to facilitate computations of such a nature is given herewith.

λ	Correction to velocity corresponding to a change of +.001 in the assumed value of λ	Correction to λ which would cause a residual of +1 km. to vanish
4200	—.0714	+.0140
4300	.0697	.0143
4400	.0682	.0147
4500	.0666	.0150

Wherever possible spectra have been reduced on the basis of solar spectrum wave-lengths, modified as above. There are some spectra, however, on or near the border line between the first and second classes which have very broad lines. These lines are so diffuse that it is impossible to tell, from their appearance, whether they are single or composite, and their character in this regard can only be inferred from an examination of the corresponding lines of stars of apparently the same class in which the lines are narrow. η *Crucis* furnishes a good example of a broad line spectrum of this class, and α *Carinae* one having narrow lines. Two spectrograms of α *Carinae* and two of υ *Carinae,* having a somewhat similar spectrum, were therefore measured, and the resulting wave-lengths were corrected for radial velocity. A number of lines as free as possible from close companions were selected to serve as a basis for reducing the spectra of the broad line stars. These are given in the following list:

λ	λ	λ
4254.51	4344.45	4501.45
58.33	51.96	08.45
60.65	83.71	15.52
62.05	86.26	20.38
84.35	4404.91	22.78
4308.06	50.66	34.19
20.99	64.64	49.72
40.61	81.39	72.15

A complete list of the lines observed in the spectra of α *Carinae* and υ *Carinae* will be found in the latter part of this volume.

In reducing stars of the *Orion* type, the six prominent lines $\lambda\lambda$4267, 4341, 4388, 4438, 4472, and 4481 have been chiefly used. The wave-lengths of some of these lines have been determined in the laboratory by Hartmann, Range and Paschen. Dr. Albrecht has investigated their wave-lengths in stars and finds it necessary to apply small corrections to some of them to harmonize

the velocity determinations from the several lines. Dr. Albrecht's values which have been used in these reductions are as follows:

λ
4267.280
4340.634
4388.100
4437.718
4471.693
4481.375

In a number of cases it seemed advisable to adopt special wave-lengths for particular stars. and in such instances attention is called to the fact in notes attached to the observations.

Spectrograms of the Moon, *Venus*, and *Mars* were secured at intervals during the period of observation to serve as controls on the work.[6] These have been measured and reduced by the revised system of wave-lengths referred to above. They seem to show a small systematic error, less in amount than the probable error of measurement of a single plate. The individual residuals are tabulated in the following columns:

Venus.		*Mars.*		Moon.	
Plate number	Residual O — C	Plate number	Residual O — C	Plate number	Residual O — C
59 III	+ .72	574 IV	+.42	35 II	+.63
76 II	+1.02	629 IV	—.05	331 III	—.20
90 III	— .71	665 III	+.47		
116 IV	— .27	738 III	+.40		
207 IV	+ .45	753 III	—.39		
245 II	+ .66	781 II	—.07		
Means	+ .31		+.13		+.22

General mean, O — C: +0.22 km.

This error does not appear to be due to the changes entering into the revision of the system of wave-lengths, as a residual of the same magnitude and sign develops when the measurements are reduced by the original Rowland values.[7] Considering this small quantity to represent the systematic error of the apparatus, together with those of measurement and reduction, all the observations secured with the $H\gamma$ region central on the plate have been corrected by the amount:

—0.22 km.

Reduction of Plates having λ4450 Central.—Referring now to the instrumental arrangement designated by (*b*) on page 74, we recall that the plates taken under these conditions are comparatively few in number, totaling only 98. On account of this fact it was decided not to enter upon a detailed discussion of the results based upon them. It should be said, however, that two systems of reduction were used in handling these measurements, some plates being reduced by one system and others by the other, while in a few cases reduction was accomplished by both. These systems will be referred to in the following pages as Systems I and II.

SYSTEM I.—This method of reduction corresponds in principle with that adopted for the treatment of the plates having the $H\gamma$ region central, and described in the foregoing paragraphs, except that no attempt was made to improve the wave-lengths given in Rowland's table. The reduction table depends, of course, on the assumed wave-lengths of both comparison and stellar lines. The comparison element in this case is titanium, and, as has been remarked, there is reason

[6] One series of observations of *Venus* made between November, 1904, and January, 1905, has not been used for this purpose, as the planet was observed early in the evening while the temperature of the spectrograph was changing rapidly. It may be stated however that the rejected observations are quite in accord with the others.

[7] The results given on page 61 were computed using the original Rowland wave-lengths, and the mean residual of the check plates is +.21 km. The adoption of the new system has, however, slightly modified some of the stellar velocities as given on that page.

to believe that Rowland's values of the wave-lengths of some of the titanium lines in this region of the spectrum are subject to considerable uncertainty. It was therefore deemed advisable to check the system independently. A comparison of the lines common to the standard table of System I and that of System II, about to be described, showed that the velocities determined by I should be .23 km. less than those reduced by II. The correction to II as derived in the following paragraphs is .00 km. This would indicate a correction of +.23 km. to be applied to observations reduced by System I. Four spectrograms of the Moon have been reduced by this system. The observations are as follows:

Date	Velocity Observed	Computed	O — C
1904 Sept. 21	—0.27 km.	—0.39 km.	+0.12
Oct. 29	—0.44	—1.48	+1.04
Nov. 14	+0.61	—0.05	+0.66
Dec. 17	+0.11	+0.73	—0.62

The mean of these residuals corresponds to a correction of —0.30 km.

A comparison of the stellar velocities reduced by System I with those determined from the $H\gamma$ spectrograms of stars not suspected of having variable velocities indicates the necessity of a correction of +0.04[8] km. to make the mean of the results accordant. As the mean of these corrections is practically zero, no correction has been applied to the measurements reduced by System I.

System II.—This system of reduction is based on a method described by Dr. R. H. Curtiss.[9] Spectrograms of the sky and Moon, with titanium comparison spectra, were secured in the ordinary course of observing. A number of these were carefully measured, and the measured positions of the solar lines, corrected for the motions of the Moon and Earth, were tabulated. A comparison of the measured positions of the lines in a stellar spectrum with this table establishes the velocity of the star. The table used rested on the measurement of two spectrograms of the Moon and two of the sky. In determining the correction of this system by means of check spectrograms of the Moon it is therefore considered that there are four plates for which the residuals are zero. An extended series of observations of *Venus* was secured with this region of the spectrum central, but these plates are among those referred to in the footnote on page 78 as having been taken early in the evening, when the temperature of the instrument was falling rapidly, a condition so unfavorable for accurate spectrographic work that the observations have not been used. The following residuals (observed — computed) are from lunar spectrograms:

Date	Velocity Observed	Computed	O — C	
1904 Nov. 13	+0.76	+0.83	—0.07	
Nov. 14	—0.08	—0.05	—0.03	
			.00	Hypothetical residuals of plates used in constructing table
			.00	
			.00	
			.00	

These residuals indicate that the systematic correction for System II is sensibly zero.

Gathering together the three systematic corrections, corresponding to the three methods of reduction we have

	Systematic correction
(a) $H\gamma$ central	—0.22
(b_1) λ4450 central system I	0.00
(b_2) λ4450 central system II	0.00

[8] Fourteen stars were used for this purpose.

[9] *A Proposed Method for the Measurement and Reduction of Spectrograms for the Determination of the Radial Velocities of Celestial Objects. Lick Observatory Bulletin*, 3, 19, 1904; also, *Astrophysical Journal*, 20, 149, 1904.

Accuracy of Results.

With instruments of good design the accuracy of a radial velocity determination is, generally speaking, a matter depending almost entirely on the character of the star's spectrum. Except in rare cases, errors due to instrumental causes are small in comparison with the errors of bisection of the broad and nebulous lines to be found in many spectra. The question of the determination of probable errors by residuals from the mean in a large list of stars is complicated somewhat by the fact that any large group of stars is almost certain to contain some which have slight variations in velocity, of the order of the probable errors of measurement. In the course of the present work a number of stars which gave at first unsatisfactory residuals proved later to be spectroscopic binaries. Any estimate of the probable error, based on the residuals of a large number of stars, is therefore likely to be too large. Of the stars contained in this catalogue a selection was made which included all those in the spectra of which the lines are numerous and fairly sharp, and a study was undertaken of their residuals. Proved spectroscopic binaries were of course excluded from this list, and the stars *ε Columbae* and *ε Carinae* were likewise omitted, the former by reason of their being little doubt as to its variability, and the latter because of the composite nature of its spectrum as announced by Miss Cannon. Only those observations made with the Hγ region central on the plate were used. Quite a number of stars are included, the constancy of whose velocity seems open to doubt. It is unnecessary to give the details of the exceedingly elementary computations here. The facts of interest are that the number of stars included in the discussion is 84, the number of observations 331, and the computed value of the probable error of an observation, which we shall call r_s, is $r_s = \pm.58$ km. The observations of a few of the stars are quite discordant. The following five, taken by themselves, give a value of the probable error exceeding unity: *β Columbae,* $5^h\ 47^m$; B *Carinae,* $8^h\ 7^m$; *β Pyxidis,* $8^h\ 36^m$; *π Pavonis,* $17^h\ 59^m$; *γ Sagittarii,* $17^h\ 59^m$. If we assume that the velocities of these stars are actually variable,[10] and exclude them from the discussion, the value of r_s becomes $\pm.54$ km. This quantity is still greatly in excess of that sometimes determined from observations of a single star. For instance the value given by our 8 observations of *α Carinae* is $\pm.3$ km., while measures of the spectroscopic binary *δ Canis Majoris,* made both at Mt. Hamilton and in Chile, appear to be equally accordant. It seems probable that many of the stars on our list will eventually prove to have variable velocities, and it may be necessary at some future time to revise this estimate of the probable error.

Turning now to the lunar and planetary observations, we find that the probable error, which may be designated by r_p, as determined from the residuals of 16 plates of the Moon, *Venus,* and *Mars,* using only those having the Hγ region central, is $r_p = \pm.42$ km.,[11] but in these cases, since we are measuring the solar spectrum, the uncertainty due to errors in the assumed wave-lengths of the lines is reduced to a minimum and we should therefore expect r_p to be less than r, the actual probable error of a single observation. As we have seen r should be less than r_s, that is,

$$.42 < r < .58.$$

We shall therefore assume, for the purposes of this discussion, that

$$r = \pm.5 \text{ km.},$$

r being, as has been said, the probable error of a single observation of a star whose spectrum contains good and fairly numerous lines. Where the spectral lines are broad and diffuse and few in number the corresponding quantity is naturally much larger, but it is not believed that

10 Since the above was written the velocity of one of these stars, *γ Sagittarii,* has been proved to be variable.

11 The observations of *Mars* and the Moon seem to be somewhat more accordant than those of *Venus.* This may be purely a matter of chance, but we are inclined to ascribe some of the difference in this respect to the fact that in photographing the latter object the telescope and spectrograph are in unusual and comparatively unfavorable positions, as *Venus* is always observed rather close to the horizon. The probable error from eight plates of *Mars* and the Moon is ± 0.26 km.

it will exceed ±3 km. for a good observation of any star in the catalogue, nor is it deemed probable that that figure will be approached except in one or two cases. Since there are, on the average, four or more observations of each star, the probable error of the catalogue value will be about half that of a single observation. That is for a star having an easily measurable spectrum the catalogue probable error will be ±.25 km.

Tables Containing Details of the Observations.

The tabulation of the details of the observations in the following pages requires little explanation. The coördinates of the stars correspond to the epoch 1900. Below the name of the star is given its visual magnitude, according to the *Revised Harvard Photometry*.[12] Under Type is given the spectral classification by Miss Cannon.[13] Below the date of observation are the last four figures of the corresponding Julian day. The complete number is found by prefixing 241 to these. The observers are indicated by their initials: A standing for Dr. Albrecht, P for Dr. Palmer, R.H.C. for Dr. R. H. Curtiss and W for Mr. Wright. One observation, made by Mr. G. F. Paddock, is designated Pk. Under λ are given the assumed wave-lengths of the stellar lines.[14] The body of the table contains the radial velocities determined from the lines set opposite them in column one. The scale correction found in the lower part of the table is applied to correct the velocity for the slight difference in scale between the standard plate on which the reduction table is based and the plate under consideration. The systematic corrections applied have been discussed in the foregoing paragraphs.

As to the parts taken by the various observers in this investigation something has been said in Director Campbell's brief account of the organization of the expedition in the opening pages of this volume. The names of the observers are attached to the observations in the following pages, and more detailed information on this subject is thereby furnished. Dr. Campbell's activities in this connection are only partially referred to in his brief introduction. The work of the expedition has been carried out under his general direction, along lines originally conceived by himself, and throughout its course he has given freely of his time, energy, and the fruit of his mature judgment. Dr. Palmer's connection with the work ended in April, 1906, with his resignation from the Lick Observatory, and Dr. Albrecht became actively associated with it a little later in the same year. Those familiar with the very considerable amount of labor which enters into an accurate observation of the velocity of a star in the line of sight will readily appreciate the great extent of the work of these gentlemen, as indicated by the occurrence of their names in the following pages. During the years 1904-5 a number of spectrograms were measured by Dr. R. H. Curtiss, and these will be found under his name. Grateful acknowledgments are due to Dr. H. D. Curtis and Mr. G. F. Paddock for their efforts in making numerous observations for the purpose of confirming suspected cases of variable velocity. In some of the reductions, and particularly in the labor of preparing the manuscript for publication, Miss Adelaide M. Hobe, Carnegie Institution Assistant, has rendered great assistance.

[12] *Annals H. C. O.*, 50.
[13] *Annals H. C. O.*, 28, Part 2.
[14] See pages 75-78.

ε Phoenicis R. A. $0^h\ 4^m4$ Dec. — 46° 18′

Magn. 3.9 Type K

Date	1903 Nov. 19.61	1904 Sept. 11.81		1904 Nov. 6.65		1905 Aug. 23.70	1905 Nov. 20.63	1905 Nov. 25.63	
Julian day	6438.6	6735.81		6791.65		7081.70	7170.63	7175.63	
Plate number	52 I	413 IV		457 II		779 III	830 II	839 II	
Photographed by	P.	W.		P.		W.	W.	W.	
Measured by	P.	W.	P.	W.	P.	P.	W.	P.	A.
λ									
4238.980	+16.3					—11.0		+12.7	+15.4
45.435									13.9
46.968	10.3					13.3	+14.2	12.0	14.7
50.287	12.5					11.8	13.7	14.6	14.5
50.962						11.3	12.4	14.0	14.5
54.505						12.5	14.1		
74.935	12.6					11.7	14.4	14.0	14.1
78.390						12.0	16.8		
82.565	17.0						15.9		
83.169							15.9		
84.382	11.2								
87.605	13.9						16.4		
88.162									13.8
94.273	10.9					13.6		14.0	14.9
13.034									13.6
4313.771	14.3								
18.867	15.7					12.4	16.5	14.4	14.9
25.195	17.0					12.5	15.4	13.4	13.7
25.978							11.7		
28.101	14.4					11.8	14.1	14.6	
37.216	10.4	λ4450 central. System II.	λ4450 central. System I	λ4450 central. System II	λ4450 central. System I	12.7	10.7	14.2	14.1
40.634	13.9					14.5	15.8	14.7	15.4
52.972	14.8					13.2		13.3	13.3
55.294	12.0								
59.784							12.8		
69.924	9.0						12.3		
71.363	11.8					8.9		14.9	15.2
75.119	14.9								
76.107	12.7						10.1	13.5	12.9
79.396	9.2						9.8	16.5	16.0
90.118	8.3					15.3		15.1	13.0
91.152						10.7		12.4	15.7
95.270						14.0		14.6	12.9
99.907	13.6					14.3			10.8
4406.810	11.2					11.3	13.6	14.4	13.0
07.850	14.9					13.1	17.2	10.3	13.4
15.312						13.8			
18.542	13.9								
27.444							14.8		
30.785	12.5								
33.414	14.7								

ε Phoenicis—(Continued)

Date	1903 Nov. 19.61	1904 Sept. 11.81		1904 Nov. 6.65		1905 Aug. 23.70	1905 Nov. 20.63	1905 Nov. 25.63	
35.817	15.6	λ4450 central. System II	λ4450 central. System II	λ4450 central. System I.	λ4450 central. System I.	12.7	13.3	13.1	14.3
41.861	12.1					13.2		9.0	10.8
42.510	14.1					10.8	13.0	13.5	13.4
43.976	11.7								
47.915	13.4					13.3		13.1	12.1
66.789	12.8					9.4		11.7	10.7
68.673	11.8					9.2		13.0	13.9
76.211	15.3					11.8		12.2	
82.361	14.8					10.6		15.3	18.5
Number of lines	(37)	(30)	(43)	(30)	(24)	(30)	(24)	(28)	(30)
Mean	+13.12	−8.07	−5.37	+12.75	+13.58	−12.22	+14.08	+13.53	+13.91
Scale Corr.	− .01	+0.17	+ .01	+ .01	.00	+ .02	− .03	+ .03	− .03
Systematic Corr.	− .22	.00		.00		− .22	− .22	− .22	
v_s	+12.89	− 6.63		+13.17		−12.42	+13.95	+13.50	
Reduction to ⊙	−22.11	− 4.58		−20.65		+ 2.87	−22.25	−22.55	
Observed V	− 9.22	−11.21 wt. ½		− 7.48 wt. ½		− 9.55	− 8.30	− 9.05	

Mean $V = -9.09$ km.

Mean J. D. 2416926.06
Epoch 1905.22

ζ Tucanae R. A. 0^h 14^m9 Dec. — 65° 29′

Magn. 4.3 Type F8G

Date	1903 Nov. 17.65	1904 Sept. 26.75		1904 Nov. 2.66	1905 Sept. 18.65	1905 Nov. 23.64	1905 Nov. 30.59
Julian day	6436.65	6750.75		6787.66	7107.65	7173.64	7180.59
Plate number	50 II	425 III		455 II	798 II	833 II	840 II
Photographed by	W.	P.		P.	W.	W.	W.
Measured by	W.	P.	W.	W.	W.	W.	W.
λ							
4246.968	+27.8				+17.7	+25.3	+25.6
50.287	25.1				18.8	22.6	20.4
50.962	25.1				16.2	23.8	23.8
54.505	30.1				16.3	26.6	24.3
74.935	23.6				19.3	29.1	25.2
78.390						27.1	
82.565	26.9					26.6	
83.169	23.9				15.9	26.2	
87.605	27.7				21.0		
4300.732	26.6						
13.771	23.9					24.2	27.1
18.867	23.3	λ4450 central. System I	λ4450 central. System II	λ4450 central. System II	15.7	21.6	18.4
20.990	25.2						
25.195					15.1	21.4	24.2
25.939	27.1				19.0	28.2	28.5
37.216						28.2	
40.634	28.3				20.8	28.3	23.6
51.960	30.6					29.1	25.8
52.949						21.1	19.7
59.784	28.6				19.8	25.0	22.8
76.107	25.4					26.9	19.4
79.396					16.3		
83.720	27.2				20.8	26.5	22.7
95.242	24.1				17.6	24.5	25.7
4404.927	26.0				18.2	25.6	27.2
06.810							26.5
07.850							23.4
27.444	24.3				14.8	27.1	21.5
35.817	29.0				22.2	26.2	25.4
42.510	26.9				18.3		26.0
Number of lines	(23)	(18)	(20)	(18)	(19)	(23)	(22)
Mean	+26.38	+21.98	+21.80	+23.96	+18.10	+25.71	+23.96
Scale Corr.	+ 0.13	— 0.01	— 0.48	+ 0.01	— 0.06	— 0.02	— 0.02
Systematic Corr.	— .22	.00		.00	— .22	— .22	— .22
v_s	+26.29	+21.64		+23.97	+17.82	+25.47	+23.72
Reduction to ⊙	—16.13	—11.03		—15.86	— 9.12	—15.91	—15.43
Observed V	+10.16	+10.61 wt. ½		+ 8.11 wt. ½	+ 8.70	+ 9.56	+ 8.29

Mean V = +9.20 km.

Mean J. D. 2416933.55

Epoch 1905.24

β Hydri R. A. 0^h 20^m5 Dec. — 77° 49′

Magn. 2.9 Type G

Date	1903 Sept. 11.71	1903 Dec. 7.62	1904 Aug. 1.75	1904 Oct. 3.69	1905 Oct. 31.64
Julian day	6369.71	6456.62	6694.75	6757.69	7150.64
Plate number	1 II	70 I	381 IV	427 II	805 II
Photographed by	W.	W.	P.	P.	W.
Measured by	P.	R.H.C.	P.	P.	P.
λ					
4222.382	+34.0				
38.980					+35.8
46.968	34.6		+29.1		35.6
50.287	33.1	+31.4	23.7		36.9
50.962	29.2		27.3		34.2
54.505	32.2	30.4			35.7
60.640		32.2			
71.325		34.5			
74.935			24.0		37.7
82.127		34.2			
82.565	30.2	33.1	25.7		
83.169		31.6	24.5		32.7
84.382			23.2		34.7
86.627	35.1				
87.605		32.9			
89.525		35.2			
94.273			20.7	λ4450 central. System I	36.8
4300.211	34.7	35.1	22.7		
13.034	34.1		.23.3		36.2
13.771		32.8			
18.867			22.0		
21.00			26.2		
25.195	30.5		21.8		33.6
25.978	28.8		23.9		34.4
28.101			21.2		
31.795			28.7		
37.216	35.1	33.5	21.4		38.1
37.725		31.3			
38.084		32.6			
40.634	35.1				37.5
43.431	37.7				
43.861		32.4			
52.949			23.8		34.8
55.294	33.9	30.8			
59.784	32.2	30.5			
69.924			23.0		33.1
71.363			26.1		37.9
76.107	37.0	30.2	26.1		
79.396		33.1			
83.720	32.7		26.9		35.7
88.629		28.4			

		36.9
		39.2
		−35.92
		— .02
		— .22
		−35.68
		—12.66
	23.06 wt. ½	−23.02

Mean J. D. 2416677.90

Epoch 1904.55

10.61 wt. ½

α Phoenicis R. A. $0^h\ 21^m3$ Dec. — 42° 51′

Magn. 2.4 Type K

Date	1903 Sept. 15.68	1903 Oct. 1.75	1903 Oct. 5.74	1904 Aug. 3.75	1904 Sept. 10.77	1905 July 16.86
Julian day	6373.68	6389.75	6393.74	6696.75	6734.77	7043.86
Plate number	2 I	24 III	32 I	384 IV	409 IV	742 IV
Photographed by	P.	P.	P.	P.	P.	W.
Measured by	R.H.C.	P.	R.H.C.	W.	P.	P.
λ						
4246.968		+86.6		+61.6		+53.2
50.287	+82.1	85.0		63.2		51.5
50.962		87.8				51.3
54.505	80.9	85.3		63.9		53.6
60.640	87.1					
65.374		93.9				
68.866		87.0		63.4		55.1
76.836	85.7					
82.565	85.2		+88.9			
83.169	82.8					
86.627						55.8
87.605	83.3	87.5		64.2		53.6
4300.211	83.0		91.8			
00.732	82.3		88.7			
13.771	82.6		91.6	64.4		52.1
18.867	81.1	85.8	91.1	62.4		53.5
25.195						52.0
25.978	80.1		87.7		λ4450 central. System I	54.5
28.101	83.3	89.2	91.7	62.5		54.2
31.795	79.9		89.9			
37.216	82.8	89.8	89.4	61.7		54.5
37.725	81.2		87.0			
38.084	80.8	89.5	85.9			
38.430		88.7				
40.634	81.0	85.9	86.4	62.6		52.6
41.530	83.1	90.3	88.3	67.5		56.7
43.402						55.8
47.464		89.5				
49.150	79.8	89.6	85.4	57.7		
52.972	82.6		89.0			
55.294		82.5				
59.784	82.3	86.8	85.7	62.3		55.0
66.061		90.3				
75.119	84.7					
76.107	81.4	86.4	89.4	62.2		55.4
79.396	80.7	87.9	91.3	65.0		52.3
83.720	85.8					55.2
84.373		86.7				
88.629	81.6		88.3			
90.118	84.0	92.3		65.2		56.5
99.907	82.0		87.2	66.3		53.8
4404.927	82.2		91.7	61.9		55.5

a Phoenicis—(Continued)

Date	1903 Sept. 15.68	1903 Oct. 1.75	1903 Oct. 5.74	1904 Aug. 3.75	1904 Sept. 10.77	1905 July 16.86
4406.810	84.1	89.6	87.6	64.7		52.8
15.722	80.1		90.3			
16.985	84.9		88.1			
17.857	85.4		90.0			
25.608	87.8		90.6			
28.711		90.2		65.0	λ4450 central. System I	55.0
30.785				63.2		53.4
33.414	83.6					
35.817	82.7	88.0		62.6		
41.861	79.2	86.4		61.2		54.1
42.510	82.5	90.2		64.6		54.4
43.976	81.2					53.4
47.915		90.3				52.9
66.789		84.0				52.0
68.673		85.5				52.7
76.214						53.2
Number of lines	(40)	(31)	(26)	(24)	(42)	(33)
Mean	+82.67	+88.02	+88.96	+63.31	+76.58	+53.87
Scale Corr.	+ .18	+ .23	+ .20	+ .03	— .17	+ .02
Systematic Corr.	— .22	— .22	— .22	— .22	.00	— .22
v_s	+82.63	+88.03	+88.94	+63.12	+76.41	+53.67
Reduction to ⊙	— 3.40	— 9.54	—10.94	+12.04	— 1.97	+17.04
Observed V	+79.23	+78.49	+78.00	+75.16	+74.44 wt. ½	+70.71

Velocity variable.

β Phoenicis R. A. $1^h\ 1^m6$ Dec. — 47° 15′

Magn. 3.4 Type K

Date	1903 Oct. 3.62	1903 Dec. 4.61		1903 Dec. 10.65	1904 Nov. 13.66	1905 Nov. 9.67		1905 Dec. 5.62
Julian day	6391.62	6453.61		6459.65	6798.66	7159.67		7185.62
Plate number	26 II	64 I		73 I	467 III	815 II		844 II
Photographed by	P.	P.		W.	P.	W.		W.
Measured by	P.	P.	R.H.C.	R.H.C.	A.	P.	A.	W.
λ								
4199.267		+21.6						
4202.198		17.5						
12.801		21.3						
22.382		15.8						
25.619		10.7						
31.183		18.9						
33.772		16.6						
38.980	+4.4					+16.8	+16.7	
45.435							14.5	
46.968	2.9	18.9				15.5	15.1	+18.6
48.384		20.1						
50.287	6.1	16.5	+18.6	+19.8		16.7	13.8	21.6
50.962	4.0	16.6				15.1	14.1	19.7
54.505	5.3	17.1	18.4			13.8	16.3	19.8
55.134			16.4	22.7				
57.815			22.5	20.6				
60.640		18.7		20.2				
65.374			23.5	23.0				
68.866		20.4						
71.325			21.8	21.1				
74.935	4.7				λ4450 central. System II	16.8	15.9	20.0
76.836		23.4						
78.390						15.3	12.5	19.5
82.127			23.7	21.2				
82.565	6.2	23.6	19.5	19.2		18.3	17.7	23.6
83.169	4.3	14.4		18.4				18.6
87.605	3.4	18.2	18.8	19.8				19.0
88.162							16.1	
89.525			21.0					
91.630								22.2
94.273	3.4					15.7	15.6	
4300.211			23.1	21.0				
00.732			22.9					
03.337	0.2							
06.921							16.5	
13.034							16.6	
13.771	3.1	18.9	21.8					20.1
18.867	7.5	19.6				16.9	15.5	19.6
25.195	1.9					18.1	16.5	21.8
25.978	2.7	18.8				16.6	15.1	18.4
28.101	6.0	19.3	18.4	21.0		18.1	16.7	20.1
31.795	4.3		18.1	20.1				
37.216	4.9	19.9	19.6	21.4		15.3	13.6	21.1
37.725			16.4					
38.084		20.2	17.3	15.7				
40.634	7.4	20.3	19.5	21.7		16.6	15.9	20.4
41.530	4.2		18.6					
49.150		19.0		18.1				17.6
52.972	5.5					15.0	16 8	
55.294				17.0				

β Phoenicis—(Continued)

Date	1903 Oct. 3.62	1903 Dec. 4.61		1903 Dec. 10.65	1904 Nov. 13.66	1905 Nov. 9.67		1905 Dec. 5.62
4359.784				15.9				
69.924	5.6							
71.363	9.8							
75.119	5.6					14.8	15.1	
76.107	3.8	16.9	20.8			16.8	15.1	20.6
79.396	0.2		19.6	16.7		13.7	13.2	18.7
83.720		20.6	20.8	20.2		18.7	17.6	21.2
88.629			22.0					
89.413			21.3					
90.118	3.6							
91.152						16.8	18.0	
95.270	6.2					15.9	15.9	18.8
99.907	1.7	20.7			λ4450 central. System II	15.6	15.2	
4404.927	9.0	20.4				17.1	17.0	21.7
06.810	3.5	21.8	22.0	21.8		15.4	16.4	17.1
07.850	6.5					16.6	17.0	18.7
11.240				19.7				
15.312	7.1					14.4	13.8	
16.985				20.9				
17.857				20.5				
18.542				17.7				
25.608			21.1					
27.444								19.2
28.711		26.6						
30.785		17.6						
33.414	6.9		22.0	19.0				
35.817	9.9	19.6		16.9		17.8	17.1	19.7
41.861	8.0					14.2		20.7
42.510	5.9	16.6	20.1	21.5		16.6	16.7	19.1
43.976	2.3	16.9	18.0	20.3				
47.918	7.0	17.7		18.0		16.8	16.6	
66.789	1.3							
68.673	6.6	19.7				16.2	16.4	
76.214	8.1					14.6		
82.376	5.1							
Number of lines	(43)	(38)	(30)	(31)	(29)	(33)	(35)	(29)
Mean	+5.01	+18.98	+20.25	+19.71	+16.04	+16.14	+15.79	+19.91
Scale Corr.	+ .01	+ .13	+ .02	.00	.00	.00	.00	— .05
Systematic Corr.	— .22	— .22		— .22	.00	— .22		— .22
v_s	+4.80	+19.47		+19.49	+16.04	+15.74		+19.64
Reduction to ⊙	—7.17	—20.11		—20.33	—17.99	—17.26		—20.19
Observed V	—2.37	— 0.64		— 0.84	— 1.95 wt. ½	— 1.52		— 0.55

Mean V = —1.25 km.

Mean J. D. 2416736.27
Epoch 1904.70

ν Phoenicis R. A. $1^h\ 10^m6$ Dec. — 46° 4′

Magn. 4.9 Type G

Date	1903 Dec. 15.64	1904 Oct. 18.75	1904 Nov. 18.69	1905 Nov. 14.69	1905 Dec. 1.65
Julian day	6464.64	6772.75	6803.69	7164.69	7181.65
Plate number	84 I	442 III	476 II	823 IV	842 II
Photographed by	P.	P.	W.	W.	W.
Measured by	P.	W.	W.	W.	W.
λ					
4238.980	+33.3				
46.968	34.2			+29.7	+30.3
50.287	33.1			29.6	28.3
50.962	33.7			25.7	28.6
54.505	32.8			30.1	31.0
74.935				29.5	29.8
82.565	34.2			31.9	
83.169				30.9	29.9
84.382	28.4				
94.273	30.9				
4300.211					35.7
18.867	34.4				32.5
25.195	33.8			33.0	29.5
25.978	33.0			28.9	34.2
28.101	34.3				28.6
37.216	33.5	λ4450 central. System II	λ4450 central. System II	33.9	
40.634				27.2	
59.784				29.7	34.5
69.924	27.7				31.6
71.363	33.3				
76.107	31.4				32.2
79.396	32.3				27.5
83.720	29.4			31.4	29.9
90.118	29.8				
91.152	30.3				33.1
95.270				27.2	28.4
99.907	28.3				
4404.927	33.5			30.3	34.1
07.850	33.1			30.8	32.0
15.312	36.2				
18.542	34.4				
25.608				33.0	31.0
27.444				30.3	30.7
30.785	32.7				
35.817					33.9
42.510	32.6			33.0	28.5
43.976	37.1			27.7	
66.727	36.5				
68.647	32.9				
76.211	37.1				
82.376	30.9				
85.846	32.7				
Number of lines	(33)	(27)	(24)	(20)	(24)
Mean	+32.78	+22.00	+31.05	+30.19	+31.07
Scale Corr.	+ .03	— .02	— .02	— .05	— .02
Systematic Corr.	— .22	.00	.00	— .22	— .22
v_s	+32.59	+21.98	+31.03	+29.92	+30.83
Reduction to ⊙	—20.37	—11.39	—18.43	—17.71	—19.85
Observed V	+12.22	+10.59 wt. ½	+12.60 wt. ½	+12.21	+10.98

Mean V = +11.75 km. Mean J. D. 2416899.80

Epoch 1905.14

γ Phoenicis — R. A. 1h 24m0 Dec. — 43° 50′

Magn. 3.4 — Type K5M

Date	1903 Dec. 14.58	1903 Dec. 22.63	1904 June 22.91	1904 Oct. 3.79	1904 Nov. 15.69
Julian day	6463.58	6471.63	6654.91	6757.79	6800.69
Plate number	80 I	96 I	354 IV	428 III	472 II
Photographed by	P.	W.	P.	P.	P.
Measured by	P.	P.	P.	P.	P.
λ					
4246.968	+58.0	+53.5			
63.290	67.9				
65.374	62.4	51.5			
68.866	60.1				
4318.867	57.7	57.1			
28.101	58.8	57.5	+20.9		
30.189	66.7				
30.866	62.7				
31.795	60.2	56.8	23.6		
47.464	60.4				
49.150	65.7	56.0			
55.294	59.7	55.6			
69.924		55.8	16.3	λ4450 central. System I	λ4450 central. System I
75.119	65.6				
76.107	59.7	52.0	23.1		
79.396		59.0	18.3		
89.413	61.8	56.1			
90.143	59.0	58.6			
4406.810	61.7		17.8		
28.711	56.9				
35.817	59.5				
38.006	57.4				
41.861	57.4	56.2			
42.510	62.4	55.7	16.5		
47.918	54.2	55.3	12.7		
66.789	58.0	55.2			
68.745	56.5	56.3			
82.376	59.8		18.2		
84.392			17.6		
85.846			22.4		
89.911	63.9	58.1			
4501.445	62.0	55.6	17.7		
05.003	61.5		22.9		
12.906	61.0	59.9			
Number of lines	(30)	(20)	(13)	(29)	(21)
Mean	+60.62	+56.05	+19.08	+20.04	+50.20
Scale Corr.	+ .06	— .08	+ .10	.00	.00
Systematic Corr.	— .22	— .22	— .22	.00	.00
v_s	+60.46	+55.75	+18.96	+20.04	+50.20
Reduction to ⊙	—20.42	—20.58	+19.84	— 5.25	—17.24
Observed *V*	+40.04	+35.17	+38.80	+14.79 wt. ½	+32.96 wt. ½

Velocity variable.

δ Phoenicis R. A. $1^h\ 27^m0$ Dec. $-49°\ 35'$

Magn. 4.0 Type K

Date	1903 Nov. 20.67	1903 Dec. 21.61[15]		1904 Oct. 17.76	1905 Nov. 10.71	1905 Dec. 6.67
Julian day	6439.67	6470.61		6771.76	7160.67	7186.67
Plate number	54 I	93 I		439 III	819 III	845 II
Photographed by	P.	P.		P.	W.	W.
Measured by	P.	W.	R.H.C.	P.	W.	W.
λ						
4222.382	+ 9.0					
32.887	12.9					
33.772	11.1					
41.285	7.1					
46.968	12.7	+15.5			+10.4	+12.1
50.287	8.6	12.4	+13.4		6.7	12.1
50.962	10.5	13.7			9.5	11.7
54.505	12.6	15.4	14.8		8.3	11.2
55.134	7.6		14.0			
65.374			14.7			
74.935		16.7			9.1	13.1
78.390		12.9			6.9	
82.127			16.0			
82.565	11.7					
83.169			12.4			
87.605	11.6			λ4450 central. System I	8.4	
91.630					10.1	
94.936	10.4					
4313.771		14.9	15.5		8.6	
18.867	12.0	14.4	13.7		11.6	
25.195	13.1	13.7			8.4	11.2
25.978	10.4	15.5			6.0	13.8
28.101	9.1	12.7	14.8			7.8
37.216		15.4	15.7		7.9	
38.084			13.1			
40.634	11.4	16.5	16.8		8.2	12.2
41.530			17.7			
43.431	9.6					
49.150					6.9	7.6
52.972			14.3			
55.294	11.5					
59.784	8.5	11.7			9.9	10.3
69.924		14.9				
75.119					8.2	
76.107	9.8		12.7		7.1	
79.396	9.1	13.9	13.9			
83.720					11.0	
91.152		16.4			12.9	11.8

15 The glass plate on which this negative was secured is badly curved, so that the center of the spectrogram, where practically all the measuring is done, was about .35 mm. out of focus in the spectrograph. The rather large residual given by this observation is probably due to this fact. The resulting velocity has not been included in making up the general mean.

δ Phoenicis—(Continued)

Date	1903 Nov. 20.67	1903 Dec. 21.61[15]		1904 Oct. 17.76	1905 Nov. 10.71	1905 Dec. 6.67
4395.270		11.4			9.6	9.4
99.907	13.0					
4404.927		15.5			10.9	
06.810	10.4	11.3	10.6		10.9	10.9
07.850		14.4			7.0	11.3
11.240			13.6			
17.857			13.1			
27.444		14.8			8.0	13.7
28.711	11.9					9.6
33.414			14.4			
35.817	8.0	12.5	13.1	λ4450 central. System I		8.1
41.861	8.0	13.0			10.6	11.8
42.510	12.6	15.5	15.2		13.0	10.2
43.976	9.2		17.4			
47.915	7.1		12.8			
68.673	10.8					
76.214	11.5					
82.376	11.2					
84.392			15.9			
4501.445	11.8					
Number of lines	(34)	(25)	(25)	(42)	(27)	(20)
Mean	+10.46	+14.20	+14.38	+ 3.09	+ 9.11	+11.00
Scale Corr.	.00	+ .06	— .02	.00	— .01	— .03
Systematic Corr.	— .22	— .22		.00	— .22	— .22
v_s	+10.24	+14.09		+ 3.09	+ 8.88	+10.75
Reduction to ⊙	—16.87	—18.42		—10.03	—15.40	—18.39
Observed V	— 6.63	— 4.33[15] wt. = 0		— 6.94 wt. ½	— 6.52	— 7.64

Mean V = —6.93 km.

Mean J. D. 2416906.54
Epoch 1905.16

χ Eridani R. A. $1^h\ 52^m\!.0$ Dec. — 52° 7′

Magn. 3.7 Type G5K

Date	1903 Nov. 22.69	1904 Aug. 26.88	1904 Dec. 8.63	1905 Nov. 18.69
Julian day	6441.69	6719.88	6823.63	7168.69
Plate number	57 I	395 III	482 II	826 III
Photographed by	W.	P.	P.	W.
Measured by	R.H.C.	W.	A.	P.
λ				
4238.980				+ 5.7
46.968		—12.9		7.9
50.287	+ 9.4	12.7		7.2
50.962		14.6		7.3
54.505	8.9	10.6		9.0
55.134	6.8			
65.374	13.1			
67.543	10.7			
68.866	12.7			
71.325	10.6			
74.935		11.9		9.0
82.127	13.5			
82.565	10.4			
83.169			λ4450 central. System II	6.1
87.605	12.1			8.0
94.273				8.6
4303.337	10.1			
13.771	14.0			8.3
18.867		11.7		4.9
25.195				8.6
25.978				11.0
28.101	13.7	9.5		11.3
31.795	10.6			
37.216	7.4			11.0
37.725	11.2			
38.084	9.9			
40.634				10.0
41.530	9.8			
49.150	11.2			
52.949				9.5
55.294	6.1			
59.784	9.4	9.9		
69.924		13.4		
71.363				10.6
75.119	9.7			
76.107	10.8	10.5		6.7
79.396	12.9			7.5
88.629	6.9			
89.413	10.9			
95.270		14.0		6.7
99.907				8.1

χ *Eridani*—(Continued).

Date	1903 Nov. 22.69	1904 Aug. 26.88	1904 Dec. 8.63	1905 Nov. 18.69
4404.927		8.9		5.8
06.810	8.8	7.4		10.1
07.850		11.7		8.4
11.240	12.8			
15.312				7.7
15.722	6.3		λ4450 central. System II	
18.542	9.9			5.3
25.608	12.3			
27.444	13.3	8.4		
30.785				5.0
33.414	7.1			
42.510	9.0			7.9
43.976	13.7			
47.915	8.3	9.8		6.6
66.789				8.6
68.673				5.1
76.214				7.6
82.376				7.5
Number of lines	(36)	(16)	(44)	(34)
Mean	+10.41	—11.12	+12.85	+ 7.90
Scale Corr.	— .01	— .14	— .02	— .01
Systematic Corr.	— .22	— .22	.00	— .22
v_s	+10.18	—11.48	+12.83	+ 7.67
Reduction to ⊙	—15.03	+ 5.53	—16.41	—14.60
Observed V	— 4.85	— 5.95	— 3.58 wt. ½	— 6.93

Mean V = —5.58 km.

Mean J. D. 2416783.47
Epoch 1904.83

ι Eridani R. A. $2^h\ 36^m7$ Dec. — 40° 17′
Magn. 4.1 Type K

Date	1903 Dec. 17.65	1904 Oct. 14.82	1904 Oct. 29.64	1904 Dec. 22.65
Julian day	6466.65	6768.82	6783.64	6837.65
Plate number	86 I	435 III	451 II	505 II
Photographed by	W.	W.	W.	P.
Measured by	P.	P.	P.	P.
λ				
4199.267	+13.6			
4203.730	5.7			
22.382	8.4			
31.183	5.4			
33.772	8.9			
38.970				+ 5.7
41.285	7.1			
46.968	10.3			6.6
50.287	8.0			5.6
50.962	8.6			7.8
54.505	7.4			4.4
74.935				9.0
86.627	13.4			
87.605	9.9			
4313.771	·			9.7
18.867	5.7			12.5
25.195				12.0
25.978				12.8
28.101	9.3			12.6
37.216	9.0	λ4450 central. System I	λ4450 central. System I	13.2
40.634	8.5			10.9
59.784				6.7
69.924				6.8
71.363				11.0
76.107	5.7			12.0
79.396	8.3			9.4
90.118				10.4
95.270				11.6
99.907	9.3			8.0
4404.927				11.0
06.810	8.0			11.4
28.711	7.8			
30.785	8.7			
33.414				9.6
35.817	8.8			14.7
41.861	9.1			8.9
42.510	9.4			10.3
43.976	7.4			
47.915	8.5			6.1
66.789	8.4			9.2
68.673	9.9			13.2
76.214				9.2
85.846				8.4
89.911	6.5			
Number of lines	(30)	(30)	(31)	(31)
Mean	+ 8.50	— 8.39	—2.14	+ 9.71
Scale Corr.	.00	.00	.00	.00
Systematic Corr.	— .22	.00	.00	— .22
v_s	+ 8.28	— 8.39	—2.14	+ 9.49
Reduction to ☉	—17.52	— 1.77	—6.11	—18.16
Observed V	— 9.24	—10.16 wt. ½	—8.25 wt. ½	— 8.67

Mean V = —9.04 km. Mean J. D. 2416693.51
Epoch 1904.59

β Fornacis R. A. $2^h\ 44^m9$ Dec. — 32° 50′

Magn. 4.5 Type K

Date	1904 Dec. 6.68	1904 Dec. 19.68	1905 Aug. 25.80	1905 Nov. 13.76
Julian day	6821.68	6834.68	7083.80	7163.76
Plate number	478 II	501 II	786 IV	822 III
Photographed by	W.	W.	W.	W.
Measured by	A.	P.	A.	P.
λ				
4238.980		+39.9	+ 1.6	+24.3
45.435			+ 1.3	
46.160			+ 2.6	
46.968		35.3	+ 1.7	27.5
50.287		37.0	+ 2.6	27.7
50.962		35.7	+ 0.7	24.1
54.505			+ 1.4	26.6
68.866			+ 2.6	
74.935		36.1	+ 2.5	26.0
82.565		36.4		28.6
83.169		31.4		22.6
84.382		34.2		
88.162			+ 1.2	
94.273		36.0	+ 1.7	26.4
06.921			+ 1.5	
4313.771			+ 2.5	25.3
14.357			+ 3.4	
18.867		42.0	— 1.6	26.8
21.00		33.1		
21.898			+ 4.8	
25.195	λ4450 central. System II	36.8		28.9
25.978		42.7		
28.101		42.9	+ 0.5	25.3
31.795			+ 0.7	
34.101			+ 2.6	
37.216		37.3	+ 1.6	26.9
39.723			+ 2.3	
40.634		39.5	+ 2.5	29.2
44.625			+ 3.0	
52.972		41.3	+ 0.8	27.9
59.784			+ 0.6	
69.924		37.0	+ 1.3	
71.363		40.0	+ 1.9	28.1
76.107		35.7		27.9
79.396		34.0	+ 0.8	19.1
90.118			+ 0.8	25.4
95.270		39.2	+ 1.3	27.3
99.907		38.8		
4400.675			+ 0.8	
01.611			+ 2.1	

β Fornacis—(Continued)

Date	1904 Dec. 6.68	1904 Dec. 19.68	1905 Aug. 25.80	1905 Nov. 13.76
4404.927		32.3		
06.810		35.9	+ 1.8	28.7
07.850		39.0	+ 0.6	25.7
15.312			— 2.2	
17.857				24.4
18.542				27.0
27.482	λ4450 central. System II		+ 0.2	
33.414			+ 1.0	
34.060			+ 1.6	
35.214			+ 0.4	
41.861		34.3		25.8
42.510		39.6	+ 1.2	28.0
47.915		36.5	+ 1.2	26.2
59.324			— 0.2	
60.486			+ 1.6	
66.789		37.6	+ 1.1	25.1
68.673		35.3	± 0.0	22.7
76.214		40.5		26.0
82.376				27.8
Number of lines	(33)	(32)	(45)	(32)
Mean	+33.52	+37.29	+ 1.39	+26.23
Scale Corr.	.00	+ .28	.00	— .01
Systematic Corr.	.00	— .22	— .22	— .22
v_s	+33.52	+37.35	+ 1.17	+26.00
Reduction to ⊙	—16.32	—19.02	+16.29	— 9.71
Observed V	+17.20 wt. ½	+18.33	+17.46	+16.29

Mean V = +17.34 km. Mean J. D. 2416998.02

Epoch 1905.41

θ[1] *Eridani* (A.G.C. 3223) R. A. 2h 54m5 Dec. — 40° 42′

Magn. 3.4 Type A2F

Date	1904 Dec. 23.65	1905 Jan. 2.64	1905 Jan. 9.64	1905 Dec. 14.66
Julian day	6838.65	6848.64	6855.64	7194.66
Plate number	507 II	518 II	532 II	851 II
Photographed by	P.	W.	W.	W.
Measured by	W.	W.	W.	W.
λ				
4340.634			+25	+48
4481.375	{— 64 / +127}	{— 34 / +104}	+33	+53
Mean			+29.0	+50.5
Reduction to ⊙	— 17.0	— 17.8	—18.1	—15.8
Observed *V*	{— 81.± / +110.±}	{— 52.± / + 86.±}	+11.±	+35.±

Double-line spectroscopic binary.

θ[2] *Eridani* R. A. 2h 54m5 Dec. — 40° 42′

Magn. 4.4

Date	1904 Dec. 24.64	1905 Aug. 23.85	1905 Sept. 26.77
Julian day	6839.64	7081.85	7115.77
Plate number	509 II	780 IV	801 IV
Photographed by	P.	W.	W.
Measured by	W.	W.	W.
λ			
4340.634	+35.	— 2.	+15.
4481.375	+35.	0.	
Mean	+35.	— 1.	+15.
Reduction to ⊙	—17.	+14.	+ 5.
Observed *V*	+18.	+13.	+20.

Mean *V* = +17 km.

Mean J. D. 2417012.42
Epoch 1905.45

The lines in the spectra of both components of the double star *θ Eridani* are very broad, hazy, and difficult of measurement, and the velocity determinations are consequently subject to great uncertainty. The brighter star, referred to in this publication as *θ*[1], is a spectroscopic binary in which the spectra of both components appear and are of about equal brightness. On the plates of 1904 December 23 and 1905 January 2 the lines are double, while on the remaining two they are single. It is impossible to state whether or not the negative velocities in the first two plates refer to the same component.

The class or type of *θ*[2] *Eridani* is not given in *Ann. H. C. O.*, 28. In the region of the spectrum observed by the expedition there occur only λλ 4340.6, 4481.4 and a few other lines, all extremely broad and hazy in character.

α Fornacis R. A. $3^h\ 7^m9$ Dec. — 29° 23′
Magn. 4.0 Type F8G

Date	1903 Sept. 21.76	1903 Nov. 12.65	1904 Sept. 13.78	1905 Aug. 24.83	1905 Nov. 30.70
Julian day	6379.76	6431.65	6737.78	7082.83	7180.70
Plate number	14 II	44 I	419 III	783 IV	841 III
Photographed by	W.	P.	W.	W.	W.
Measured by	P.	A.	A.	A.	A.
λ					
4238.980	—33.4			—40.7	— 6.6
45.435					7.1
46.968	35.8			37.8	6.9
47.584					5.4
50.287	33.3	—10.8		40.4	5.8
50.962	33.5	11.2		40.7	8.0
54.505	36.0			42.2	7.7
60.640	26.7				
71.325					10.1
71.934				40.2	7.7
74.935	35.7	14.1		37.1	7.5
82.565	30.6				7.5
83.169					10.6
84.382	30.9				
88.133				41.1	7.7
93.239				40.3	
94.273	37.2			42.8	7.8
4300.211	36.3		λ4450 central. System II		
06.921					8.4
13.034	29.6			40.2	6.6
14.357		15.4		44.4	10.9
18.867				43.0	
21.00	24.6			41.7	10.5
25.195	31.5				9.7
25.939	30.8	12.8		39.0	6.5
31.795					5.3
37.216	30.1	7.7		40.8	
40.634	29.7			36.7	5.9
52.012				40.3	7.8
52.949	35.8			39.1	12.0
59.784		9.1		40.3	9.7
71.363	30.5				
75.119					10.1
76.107	32.1			41.0	8.6
79.396	35.4				
83.720	31.3	11.9		39.7	6.8
87.007				40.1	
91.152					7.1
95.242	30.6	13.2		42.7	8.5
4401.611		10.2			
04.927	30.4	9.3		40.4	7.9

[illegible] *Persei*—Continued.

Date	1905 Nov. 30.70	1905 Aug. 23.82	1904 Sept. 13.75	1903 Nov. 22.65	1903 Sept. 21.78
2407.889	31.2				3.9
08.771				39.0	
15.112		22.0			
16.066		15.8	[illegible]	36.8	
17.867					8.8
25.008	30.0				
27.844		15.2		40.6	8.0
32.814				42.5	
35.178				39.1	10.5
35.847		15.4			
41.841	32.2				
42.710	26.9				
44.975	29.5	15.2			6.7
47.915	35.8			37.5	5.7
59.824		16.6		44.2	
66.727	27.9				
69.647	35.9			39.9	9.5
76.211	34.8				
81.264	34.7				
82.276	33.1				
Number of lines	(35)	(17)	(30)	(33)	(38)
Mean	−32.11	−12.70	−36.86	−40.43	−8.08
Scale Corr.	− .08	− .02	+ .86	+ .09	+ .01
Systematic Corr.	− .22	− .22	.00	− .22	− .22
V_0	−32.41	−12.94	−35.99	−40.56	−8.29
Reduction to ☉	+11.98	− 6.21	+14.03	+18.45	−12.62
Observed V	−20.43	−19.15	−21.96 wt. ½	−22.11	−20.91

Mean V = −20.89 km.

Mean J. D. 2416762.54
Epoch 1904.77

τ^4 *Eridani* R. A. $3^h\ 15^m.1$ Dec. $-22°\ 07'$

Magn. 4.0 Type Mb

Date	1903 Nov. 19.75
Julian day	6438.75
Plate number	53 II
Photographed by	P.
Measured by	P.
Number of lines	(22)
Mean	+51.24
Scale Corr.	— .02
Systematic Corr.	— .22
v_s	+51.00
Reduction to ⊙	— 7.71
Observed V	+43.29

Mean V = +43.29 km.

Mean J. D. 2416438.75

Epoch 1903.89

As only one spectrogram of this star was secured it has not been considered necessary to publish the velocities determined from individual lines. Observations of this star have also been secured at Mt. Hamilton as follows:

	Date	Velocity
	1906 Oct. 28	+41.2
	1909 Nov. 1	+43.7
Mean		+42.4

κ Reticuli R. A. $3^h\ 27^m.6$ Dec. — 63° 18′

Magn. 4.8 Type F5G

Date	1903 Dec. 3.74	1904 Dec. 13.70	1904 Dec. 20.70	1905 Nov. 1.82	1905 Nov. 4.79	1905 Dec. 20.68
Julian day	6452.74	6828.70	6835.70	7151.82	7154.79	7200.68
Plate number	63 II	494 II	503 II	810 III	812 IV	857 III
Photographed by	P.	W.	W.	W.	W.	W.
Measured by	A.	A.	A.	A.	A.	A.
λ						
4245.435			+19.0			
46.968	+23.4				+19.1	
50.287	20.4		25.8	+18.5	20.0	+24.6
50.962	21.9		16.5	17.4	20.3	21.3
54.505			26.2	17.1	20.3	
71.325			20.7	20.1	19.8	
71.934	20.3		17.2	19.0	17.3	22.7
74.935			23.4	19.7	18.7	
82.565						21.3
83.169			21.3			
88.133					18.0	
94.273	19.9		20.6	16.4	18.6	21.6
4300.211			19.8		21.1	
13.034	20.1		24.0			
14.357	19.8	λ4450 central. System II	19.5	14.5		18.0
15.178					19.0	
18.867	21.7					
21.00	20.5		22.4	17.0		
25.195	22.3					19.4
25.939	21.7		24.2	20.0	20.0	24.8
37.216						22.1
40.634	24.1		20.8	19.3	16.6	
52.012	22.1		22.8	17.4	19.1	22.0
52.949			21.3	19.7		16.2
76.107	21.7		21.0	19.0		
83.720	22.3		21.7	16.3	19.8	20.6
95.242	23.7		25.7	15.1	18.1	22.7
4401.611					16.6	17.4
04.927	22.7		23.1	17.9	18.5	19.1
16.985			23.4			
27.444	17.9		22.0	15.2	17.8	20.4
35.178	23.2			17.0		
42.510	21.4					
43.273						20.6
43.976	24.6				19.7	18.9
47.915						21.1
50.654	20.7				18.8	
59.324	22.4		24.1	15.3	14.7	
68.647	20.4		21.3	18.6	20.3	19.7
Number of lines	(24)	(25)	(25)	(21)	(23)	(20)
Mean	+21.63	+20.18	+21.91	+17.64	+18.79	+20.72
Scale Corr.	+ .02	.00	+ .16	— .04	— .04	— .03
Systematic Corr.	— .22	.00	— .22	— .22	— .22	— .22
v_s	+21.43	+20.18	+21.85	+17.38	+18.53	+20.47
Reduction to ☉	— 8.33	— 8.53	— 8.51	— 6.16	— 6.43	— 8.50
Observed *V*	+13.10	+11.65 wt. ½	+13.34	+11.22	+12.10	+11.97

Mean *V* = +12.28 km.

Mean J. D. 2416945.47

Epoch 1905.27

β Reticuli R. A. $3^h\ 42^m 9$ Dec. — 65° 7′

Magn. 3.8 Type K

Date	1903 Dec. 7.72	1904 Jan. 4.64	1904 Dec. 18.67	1905 Nov. 5.67		1905 Dec. 28.66
Julian day	6456.72	6484.64	6833.67	7155.67		7208.66
Plate number	71 II	111 I	499 II	813 III		859 II
Photographed by	W.	W.	P.	W.		W.
Measured by	R.H.C.	P.	W.	W.	A.	W.
λ						
4190.874		+63.2				
92.728		55.1				
99.267		63.0				
4222.382		59.4				
33.772		61.3				
38.188				+51.5		
46.968		62.1	+51.2	55.3		+55.3
47.584					+54.3	
50.287	+65.4	59.0	55.0	53.7	54.7	
50.962		62.0	52.5	51.5	51.5	
54.505	61.7		52.8	51.5		
55.134	60.4					
57.815	62.3					
65.374	62.3			55.1		
71.325	60.1					
74.935			57.0	53.1		
78.390				54.8	53.9	
82.127	57.6					
82.565	64.1					
83.169	62.3					
86.627		59.6				
87.605	62.0	56.4		51.8		
88.162					52.2	
4300.211	60.9					
00.732	62.9					
13.771	65.0		52.2	50.2		53.6
14.357					53.8	
18.867		60.1	55.0	53.8	52.2	
25.195			59.3	55.8	54.9	
25.978			58.1	55.3		
28.101	63.7	59.8	52.6	52.9	53.4	56.8
31.795	63.0			53.5	50.7	
37.216	59.9	61.2	52.1	52.5	52.9	51.8
37.725	58.5					
38.084	59.0					
40.634	63.2	59.0	55.1	52.3	54.0	
41.530	63.5					
49.150			55.3			52.5
52.972					54.4	
59.784	60.9	61.8	55.4	52.8	53.0	55.0
69.924		59.5	54.3	51.3		56.5

β Reticuli—(Continued)

Date	1903 Dec. 7.72	1904 Jan. 4.64	1904 Dec. 18.67	1905 Nov. 5.67		1905 Dec. 28.66
4371.363					53.1	
76.107	62.2	59.3	55.4	52.4	52.4	53.1
79.396	60.0	59.9	55.0	53.7	54.6	55.7
88.629	60.4					
89.413	64.9					
90.118			52.2	53.3	53.4	
95.270			55.5	55.6		
99.907		63.6	54.0	51.7		53.7
4400.675					54.6	
01.611					52.7	
04.927			53.2	52.8		
06.810	59.2	59.6		51.3	51.8	56.8
07.850				54.2	55.1	55.0
11.240	58.1					
17.857	61.1					
27.444			53.9	52.7	51.8	54.7
28.711						56.3
33.414	65.5					
35.214					51.9	
35.817	64.0	61.8				56.0
41.861		58.2				56.5
42.510	61.9	65.1	56.6	53.7	53.6	54.9
43.976	62.1					
47.915	60.0	60.6	54.0	51.9	50.7	54.4
59.324			54.5	52.8	53.5	55.7
66.789			53.1		54.3	52.2
68.673		60.0	59.0			
Number of lines	(33)	(25)	(27)	(31)	(28)	(20)
Mean	+61.76	+60.42	+54.60	+53.06	+53.19	+54.82
Scale Corr.	+ .03	— .05	+ .67	+ .05	— .14	— .15
Systematic Corr.	— .22	— .22	.00	— .22		— .22
v_s	+61.58	+60.15	+55.27	+52.86		+54.45
Reduction to ☉	— 7.33	— 6.75	— 7.29	— 5.78		— 7.05
Observed V	+54.25	+53.40	+47.98	+47.08		+47.40

Velocity variable.

γ Hydri R. A. $3^h\ 48^m8$ Dec. — 74° 33′

Magn. 3.2 Type Ma

Date	1903 Dec. 20.65	1904 Dec. 17.70	1905 Jan. 5.68	1905 Dec. 30.64
Julian day	6469.65	6832.70	6851.68	7210.64
Plate number	91 I	497 II	523 II	861 II
Photographed by	P.	P.	W.	W.
Measured by	R.H.C.	P.	P.	W.
λ				
4246.968			+19.5	
50.287	+19.5		16.1	
50.962			21.1	
54.505	20.4			
65.320	23.7		19.9	+22.9
83.169				21.9
86.627			23.9	
87.605			17.7	
4316.962			18.8	
18.867			17.8	22.6
25.195				19.0
28.101	21.0		21.0	18.0
30.189			22.1	
30.866			23.9	
31.795			20.7	23.4
37.216	19.8	λ4450 central. System I	19.2	17.8
40.634			17.4	22.6
46.725			20.1	
47.464			16.1	
49.150	20.9			19.2
55.294	17.6		15.8	
59.784	23.3		22.4	21.7
69.924				19.3
75.119			18.0	18.0
76.107	22.3		18.0	
79.396	21.7		17.7	18.7
88.629	21.6			
89.413	20.7		18.7	
90.168			15.7	
91.152				18.3
4406.810	19.8		19.5	21.4
07.850				17.2
18.542	18.3			
25.608	20.5			
27.444				16.8
28.711			13.2	16.8
35.817				14.9
41.861			17.9	18.4
42.510	21.1		18.5	21.2
43.976	21.7			

[illegible] (Continued)

Line	1903 Dec. 20.6[illegible]	1904 Dec. [illegible]	1905 Jan. [illegible].68	1905 Dec. 30.6[illegible]
4471.[illegible]	[illegible]	[illegible]	.[illegible]	
[illegible]73			.[illegible]	
[illegible]			.[illegible]	
[illegible].15			.[illegible]	
[illegible].11			.[illegible]	
Number of lines	[illegible]	[illegible]	[illegible]	[illegible]
Mean	[illegible]0.71	−20.[illegible]3	−1[illegible]	−19.53
Scale Corr.	.3	− .16	− .[illegible]	− .[illegible]
Systematic Corr.	− .22	.0[illegible]	− .[illegible]	− .[illegible]
[illegible]	[illegible]0.46	−20.[illegible]	−[illegible]4	−19.[illegible]
Reduction to [illegible]	− [illegible].66	− [illegible]78	− [illegible]8	− [illegible]
Observed [illegible]	[illegible]5.[illegible]0	−15.[illegible]1 wt. ½	−15.56	−15.[illegible]

Mean [illegible] = [illegible]15.70 km.

Mean J. D. 24168[illegible]

Epoch 1904.[illegible]9

a Horologii R. A. 4^h 10^m7 Dec. — 42° 32′

Magn. 3.8 Type K

Date	1903 Dec. 13.72	1904 Nov. 9.66	1905 Jan. 3.70	1905 Nov. 19.79	1906 Jan. 3.68
Julian day	6462.72	6794.66	6849.70	7169.79	7214.68
Plate number	77 I	461 II	520 II	828 II	865 III
Photographed by	W.	P.	W.	W.	W.
Measured by	R.H.C.	A.	P.	A.	W.
λ					
4238.980			+34.9	+26.7	
39.965				26.3	
45.435				25.7	
46.160				25.3	
46.968			34.3	25.0	+37.6
47.584				23.0	
50.287	+29.1		32.8	25.2	33.7
50.962			33.8	24.8	36.2
54.505	32.0				29.4
55.134	26.9				
57.815	31.1			23.2	
65.374	29.7				
67.543	28.9				
68.866	32.3			23.6	
74.935			34.5	26.7	34.7
78.390			32.5	28.2	33.7
82.127	29.9	λ4450 central. System II			
83.169	31.2				
87.605	33.3				33.7
88.162				26.0	
92.304				23.8	
93.239				27.1	
94.273			31.8	23.0	
4306.921				27.2	
13.771					38.1
14.357				25.6	
18.867			34.4	25.2	35.3
21.898				25.8	
25.195			37.0		39.3
28.101	30.5		33.1	25.0	32.5
31.795	26.7			22.1	
34.101				23.3	
35.000				20.8	
37.216	30.2		33.6	24.6	33.2
39.723				25.2	
40.634	35.5		31.3	26.3	31.5
41.530	32.8				
43.861	30.4				
44.625				22.6	
49.150	32.1			25.2	
52.012				24.4	

α Horologii—(Continued.)

Date	1903 Dec. 13.72	1904 Nov. 9.66	1905 Jan. 3.70	1905 Nov. 19.79	1906 Jan. 3.68
4352.972			36.1	25.3	
59.784				25.7	34.9
69.924				24.7	37.2
71.363			33.5	24.6	
75.119	31.0				35.5
76.107	32.7		35.5	25.1	29.9
79.396	33.1		28.2	23.6	31.6
89.413	38.6				
90.718			32.7		
91.152				23.8	34.7
95.279			34.4	24.4	36.8
99.307			34.2		
01.511				24.7	
4404.027					31.4
06.810	29.6		33.7	23.8	37.3
07.850			34.3	24.5	35.1
08.571				26.6	
11.240	31.3	λ4450 central. System II			
15.723	26.9				
17.857	28.9				
18.542	30.4		33.5		
27.444				24.0	34.7
33.414	32.7		30.8	26.7	
35.214				24.1	
35.817			33.7	25.6	33.0
41.861			34.8		
42.510	29.9		35.7	26.2	37.4
43.976	28.9		32.7		
47.915	30.7		33.2	25.2	
59.324				25.2	
66.789			31.4	25.1	
68.673			33.2	26.9	
76.214			32.5		
82.376			34.1		
Number of lines	(30)	(43)	(32)	(51)	(26)
Mean	−30.56	−22.23	−33.51	−24.95	−34.55
Scale Corr.	+.04	−.01	+.17	+.04	+.08
Systematic Corr.	+.22	.00	+.22	+.22	+.22
V	−30.30	−22.24	−33.12	−24.69	−34.25
Reduction to ⊙	+8.72	+0.78	+12.44	+3.45	+12.37
Observed V	−21.58	−21.46 wt. ½	−20.68	−21.24	−21.88

Mean V = −21.36 km.

Mean J. D. 2416909.83
Epoch 1905.17

α Reticuli R. A. $4^h\ 13^m1$ Dec. — 62° 43′

Magn. 3.4 Type G5K

Date	1903 Sept. 15.79	1903 Nov. 11.69		1904 Oct. 12.77	1905 Nov. 9.77
Julian day	6373.79	6430.69		6766.77	7159.77
Plate number	3 II	41 II		430 III	816 III
Photographed by	P.	P.		P.	W.
Measured by	P.	P.	A.	P.	A.
λ					
4199.267	+37.4				
4212.801	36.2				
22.382	34.6	+42.1			
31.183		39.4			
33.772	34.2	38.2			
39.965			+38.3		
45.435			39.7		+38.4
46.968	36.2	39.8	39.2		40.3
47.584					39.0
50.287	31.2	37.6	37.8		38.6
50.962	34.3	40.9			38.1
54.505		41.3	38.9		37.9
55.134		42.3			
63.290	37.7	45.4			
65.374		45.6			
68.866	35.7				
71.325				λ4450 central. System I	39.2
74.935			40.4		40.7
78.390					39.1
82.565	37.6	41.4			40.8
83.169	30.4				
86.627		44.1			
87.605	31.7	40.6			
88.162			38.8		
93.239			38.7		40.1
94.273			38.6		38.1
4306.921					40.7
13.771		39.7			
14.357			40.1		41.6
18.867	33.7	41.0	40.6		41.0
25.195		38.4			
25.978					39.3
28.101		39.4	39.1		
31.795			38.1		
37.216	34.6	40.1			41.3
37.725	33.8				
38.084	31.7	40.0			
40.634	29.5				39.4
41.530	33.3				
43.431		39.5			
44.625					37.5

α Reticuli—(Continued)

Date	1903 Sept. 15.79	1903 Nov. 11.69		1904 Oct. 12.77	1905 Nov. 9.77
4347.464		36.2			
49.150		42.2			
52.949			41.5		40.2
55.294		41.5			
59.784	32.2	40.0	42.0		40.2
75.119					39.3
76.107	33.8	39.5	38.5		
79.396	30.6	41.6			
88.629		41.4			
89.413		43.2			
90.118		41.8			
91.152					39.8
95.270			40.1	λ4450 central. System I	39.6
99.907	32.7	41.7			
4400.675			39.8		
01.611					37.7
06.810	34.7	42.3			
08.571			39.0		37.7
17.857	40.0	44.8			
27.444			37.8		38.0
28.711		40.2	42.8		
30.785		41.6			
35.214			38.2		38.7
35.817	30.7	40.6			
41.861		40.1	39.4		
42.510	33.9	42.2	40.4		40.2
43.976		40.6			
44.728	27.5				
47.915		38.6	38.9		40.9
57.656			36.3		
59.324			39.2		38.9
60.486			41.5		
68.673	35.7	38.2	38.6		39.9
Number of lines	(28)	(40)	(29)	(35)	(32)
Mean	+33.77	+40.88	+39.39	+35.86	+39.44
Scale Corr.	+ .06	+ .03	+ .03	+ .02	— .01
Systematic Corr.	— .22	—.22		.00	— .22
v_s	+33.61	+39.94		+35.88	+39.21
Reduction to ☉	+ 1.49	— 4.22		— 1.48	— 4.20
Observed *V*	+35.10	+35.72		+34.40 wt. ½	+35.01

Mean *V* = +35.15 km.

Mean J. D. 2416670.75
Epoch 1904.53

A. G. C. 4821 R. A. $4^h\ 14^m.1$ Dec. — 34° 3′

Magn. 3.6 Type B9A

Date	1903 Oct. 3.79	1904 Nov. 10.68	1904 Dec. 7.64	1904 Dec. 14.68
Julian day	6391.79	6795.68	6822.64	6829.68
Plate number	28 IV	464 III	480 II	495 II
Photographed by	P.	W.	W.	W.
Measured by	W.	W.	W.	W.
λ				
4481.375	+ 3.5	$\left\{\begin{matrix}-16.6\\+49.1\end{matrix}\right\}$	+26.9	$\left\{\begin{matrix}-\ 15.8\\+\ 72.9\end{matrix}\right\}$
Mean				
Scale Corr.	0.0	0.0	0.0	0.0
Systematic Corr.	— .2	— .2	— .2	— .2
Reduction to ☉	+11.4	+ 0.7	— 7.4	— 9.5
Observed *V*	+14.7	$\left\{\begin{matrix}-16.1\\+49.6\end{matrix}\right\}$	+19.3	$\left\{\begin{matrix}-25.5\\+63.2\end{matrix}\right\}$

Double line spectroscopic binary.

There seems to be some doubt as to the proper designation of this star in the constellation of *Eridanus*. In the *Argentine General* Catalogue and in publications which have followed the nomenclature there adopted the star is referred to as X *Eradani,* while this designation is applied in the *Harvard Catalogue of Variable Stars* to the star S. D. M. 845, $2^h\ 47^m4$, —41° 54′ (1900). In announcing the variable velocity of A. G. C. 4821 the star was referred to as X *Eridani*. On account of this confusion of terms it is here represented by its A. G. C. number alone.

The star is a spectroscopic binary in which both spectra are of about the same type and intensity. The masses of the two components appear to be very nearly equal.

d *Eridani* R. A. $4^h\ 20^m2$ Dec. — 34° 14′

Magn. 4.1 Type K5M

Date	1903 Dec. 12.76	1904 Jan. 15.64	1904 Dec. 8.74	1905 Nov. 5.81	1906 Jan. 9.66
Julian day	6461.76	6495.64	6823.74	7155.81	7220.66
Plate number	75 I	132 I	483 III	814 III	869 II
Photographed by	W.	P.	P.	W.	W.
Measured by	R.H.C.	W.	A.	P.	W.
λ					
4238.980				+21.0	
46.968				20.2	+37.6
50.287	+32.6			24.8	
57.815	29.8				
65.374					40.8
78.390				19.5	40.9
82.565	35.2				
83.169	28.2			24.7	
87.605	29.6			19.9	
94.273				13.4	
4300.211	31.0				
00.732	30.6				
13.771					42.6
18.867	32.8			22.6	
25.195				20.8	
28.101	29.4	+34.9		18.9	38.8
31.795	30.8			15.9	
37.216	30.4		λ4450 central. System II	18.5	36.8
40.634	33.8			18.4	36.2
49.150	33.3	37.3			35.5
52.990		34.7		21.0	39.4
55.294	29.1			18.1	
59.784	31.5	38.2			40.4
69.924					38.7
71.363				17.5	
75.119				19.4	
76.107	30.2	37.8		17.2	38.9
79.396	32.3			17.4	36.5
88.629	31.2				
89.413	31.5				
90.143				20.2	
91.152				19.3	37.3
95.298		37.4		16.8	34.8
4406.810	31.6			19.1	38.5
07.850		38.6		15.0	37.4
11.240	32.7				
18.542	27.0				
27.444		38.7			40.3
28.711					35.9
33.414	35.0				
35.817				24.4	40.3

d *Eridani*—(Continued)

Date	1903 Dec. 12.76	1904 Jan. 15.64	1904 Dec. 8.74	1905 Nov. 5.81	1906 Jan. 9.66
41.861				17.7	39.8
42.510	32.6	35.4	λ4450 central. System II	19.1	39.1
43.976	34.2				
47.915	30.1	38.4		21.1	
59.324		35.4			
66.789		38.0		22.4	
68.745				19.6	
76.214		39.2		20.0	
82.376		38.3		19.7	
Number of lines	(26)	(14)	(42)	(32)	(22)
Mean	+31.40	+37.31	+32.01	+19.48	+38.48
Scale Corr.	+ .01	+ .17	— .05	— .05	— .14
Systematic Corr.	— .22	— .22	.00	— .22	— .22
v_s	+31.19	+37.26	+31.96	+19.21	+38.12
Reduction to ⊙	— 8.25	—15.55	— 6.82	+ 2.63	—14.69
Observed *V*	+22.94	+21.71	+25.14 wt. ½	+21.84	+23.43

Mean *V* = +22.78 km.

Mean J. D. 2416832.39
Epoch 1904.96

υ² Eridani — R. A. $4^h\,31^m.7$ Dec. $-30°\,46'$

Magn. 3.9 — Type K

Date	1904 Jan. 3.69	1904 Sept. 9.86	1904 Dec. 26.71	1905 Dec. 14.80	1906 Jan. 22.66
Julian day	6483.69	6733.86	6841.71	7194.80	7233.66
Plate number	289 IV	446 IV	512 IV	852 III	879 III
Photographed by	P.	P.	W.	W.	W.
Measured by	P.	P.	P.	W.	W.
λ					
4217.720	−9.4				
22.382	10.4				
28.670			−8.8		
46.968	10.5		10.2	−5.1	−13.3
50.287	8.6		7.3	5.7	14.3
50.962	10.3		9.0	3.8	11.1
54.505	10.1		9.4	4.8	14.7
58.50			9.2		
65.174				3.9	17.5
68.866	12.4				
74.955			11.2	3.9	14.0
78.390			9.1	3.6	13.2
82.565				6.3	16.6
83.169				3.7	11.0
87.205					13.0
91.620					12.1
4313.771		λ4450 central. System I.	4.4	5.2	14.9
18.867	12.3		10.3	6.1	
25.195			11.1	4.2	14.7
25.978			11.9	2.2	14.4
28.101			6.9	4.9	13.4
31.795	10.9				
37.216			9.8	5.0	15.4
40.634			10.0	1.8	14.7
49.150				5.4	
55.294			11.2		
59.784	6.7		7.0	4.0	14.7
69.924			6.4		15.3
71.363			8.6		
75.119			10.9	3.4	14.2
76.107	8.1		8.2	4.9	12.0
79.396	7.0		4.9	2.5	13.1
83.720				0.8	13.2
91.152			7.7	6.1	12.6
95.270				1.0	
99.907			7.1		
4404.927			7.6	5.0	14.4
06.810	6.9		10.9	2.3	10.9
07.850				5.1	14.4
11.240			9.6		

υ^2 *Eridani*—(Continued) R. A. $4^h\ 31^m.7$ Dec. — 30° 46′

Date	1904 Jan. 3.69	1904 Sept. 9.86	1904 Dec. 26.71	1905 Dec. 14.80	1906 Jan. 22.66
4417.857			5.1		
27.444				2.4	12.0
28.711				1.6	
33.414			10.7		
35.817				5.2	12.1
41.861	11.7		6.8		
42.510	13.5		10.4	4.1	14.2
47.915	9.3	λ4450 central. System I	10.3		
66.789	10.5		9.7		
68.673	8.3		10.6		
76.214	9.2		9.3		
82.376			6.6		
4501.445	13.4				
08.455	10.8				
Number of lines	(21)	(17)	(39)	(31)	(30)
Mean	+10.02	—19.25	+ 8.84	+4.00	+13.71
Scale Corr.	— .01	+ .05	.00	— .01	— .04
Systematic Corr.	— .22	.00	— .22	— .22	— .22
v_s	+ 9.79	—19.20	+ 8.62	+3.77	+13.45
Reduction to ⊙	—13.12	+17.36	—11.31	—7.97	—16.92
Observed V	— 3.33	— 1.84 wt. ½	— 2.69	—4.20	— 3.47

Mean V = —3.25 km.

Mean J. D. 2416915.73
Epoch 1905.19

α Coeli R. A. 4^h 37^m3 Dec. — 42° 3′

Magn. 4.5 Type F2G

Date	1903 Nov. 16.69	1904 Jan. 14.63	1904 Dec. 27.71	1905 Jan. 25.64	1905 Oct. 31.73
Julian day	6435.69	6494.63	6842.71	6871.64	7150.73
Plate number	48 I	129 I	513 II	556 II	807 IV
Photographed by	W.	P.	W.	P.	W.
Measured by	W.	A.	W.	A.	A.
λ*					
4215.69	+ 8		+18		
47.14		+17			— 2
54.51	+10		11		
54.58		14			
58.33			3		
58.37					— 1
60.56		5		0	0
69.65	+ 1		1		
4308.94		10			— 4
08.96	— 3		6		
20.99	+ 1		11		
21.02					— 5
25.87		4		+ 5	
40.61	+ 6		16		
40.66		12		+10	— 7
51.96			4		
52.03		16		— 2	+ 3
83.71	+ 3		3		
83.72				+ 6	
95.21			16		
95.25				+17	+ 2
4404.91	— 2		10		
04.93				+18	0
15.32				+10	+ 2
30.68		8		+ 9	
43.89				0	+ 7
64.64			16	— 5	+ 4
81.39	0	14	17	+ 5	—12
4501.45	— 4		9		
08.45			16		
15.52			9		
20.38	+ 9		9		
22.78	0		16		
49.72	+ 7		15		
72.15	+ 9		3		
Number of lines	(14)	(9)	(20)	(12)	(13)
Mean	+3.21	+11.1	+10.44	+ 6.1	— 1.0
Scale Corr.	+ .03	.0	.00	+ 0.0	.0
Systematic Corr.	— .22	— .2	— .22	— .2	— .2
V_s	+3.02	+10.9	+10.22	+ 5.9	— 1.2
Reduction to ⊙	+0.19	—11.8	— 9.22	—13.1	+ 3.8
Observed V	+3.21	— 0.9 (wt. ½)	+ 1.00	— 7.2 (wt. ¼)	+ 2.6

Mean V = + 1.22 km. Mean J. D. 2416771.83

Epoch 1904.79

The lines in the spectrum of this star are broad and hazy. The large range in the radial velocity of the star, as determined from these plates, is probably due partly to the character of the spectrum and partly to considerable underexposure on plate 556 II.

* As indicated in the first column of the table a system of wave-lengths has been used by Dr. Albrecht different from that adopted by Mr. Wright. Where the wave-lengths differ only a fraction of an Angstrom the same line is referred to.

β Leporis R. A. $5^h\ 24^m.0$ Dec. — 20° 51′

Magn. 3.0 Type G

Date	1903 Sept. 16.84	1904 Feb. 5.59	1904 Oct. 29.78	1905 Nov. 14.82	1905 Nov. 20.73
Julian day	6374.84	6516.59	6783.78	7164.82	7170.73
Plate number	8 IV	168 I	452 III	824 II	831 III
Photographed by	P.	W.	W.	W.	W.
Measured by	P.	R. H. C.	P.	A.	P.
λ					
4238.980					—21.4
39.965				—22.4	
45.435				23.2	
46.160				22.6	
46.968				22.7	21.8
47.591				25.9	
50.287		+4.2		22.0	21.9
50.962				23.6	21.5
54.505		2.9		23.0	21.3
60.640					17.2
68.866				22.3	
71.325				20.3	
71.934				22.5	
74.935				20.8	21.9
78.390				22.4	21.9
82.565	—28.4		λ4450 central. System I.	20.0	18.8
83.169	36.7	6.3		25.7	23.7
87.605		4.2			
91.630		6.1			
93.239				23.8	
94.273				21.5	21.5
4300.211				21.3	
06.921				23.5	
13.034	33.9			24.6	22.7
14.357				24.4	
18.867				22.5	21.8
21.000				24.1	
25.195				21.3	22.7
25.978	35.6			23.4	24.6
26.923	32.2				
28.101		4.8		26.0	21.7
31.795				27.3	
37.216	33.1	2.7		21.7	19.6
39.723				21.4	
40.634	32.8	7.1		21.3	19.0
43.402	32.2			21.9	
44.625				26.6	
52.012				24.1	
52.949				22.2	20.0
59.784	34.0			23.0	
71.363					20.8

β Leporis—Continued.

Date	1903 Sept. 16.84	1904 Feb. 5.59	1904 Oct. 29.78	1905 Nov. 14.82	1905 Nov. 20.73
4375.119				24.5	20.9
76.107		4.9		23.2	20.9
79.396	36.1			22.9	
83.720		3.4		22.3	22.9
84.373	28.8				
87.007				22.8	
90.118					23.3
91.152				24.0	22.6
95.270				24.0	21.3
99.907	32.2				22.0
4401.611				23.5	
04.927	34.7			21.2	22.9
06.810					23.6
07.850				21.3	21.1
08.571				24.6	
15.312				25.6	
15.722		6.5			
16.985		8.4			
17.857		7.4		21.1	19.1
27.444				24.2	
33.414		3.9			
35.178				23.7	
35.817	35.0			25.7	23.4
41.861					21.9
42.510	32.6	2.3		22.1	17.5
43.976		7.8		26.0	21.5
47.915	35.8	5.2		24.6	21.1
59.324				26.1	
66.727					24.6
68.647	35.7			22.5	20.2
76.211					22.8
82.376					19.1
4501.445	35.3				
08.455	33.6				
Number of lines	(19)	(17)	(43)	(56)	(40)
Mean	—33.62	+ 5.18	—29.08	—23.24	—21.46
Scale Corr.	— .03	— .01	— .02	.00	+ .05
Systematic Corr.	— .22	— .22	— .00	— .22	— .22
v_s	—33.87	+ 4.95	—29.10	—23.46	—21.63
Reduction to ☉	+21.40	—18.33	+14.33	+ 9.40	+ 7.28
Observed V	—12.47	—13.38	—14.77 wt. ½	—14.06	—14.35

Mean V = —13.70 km.

Mean J. D. 2416803.93
Epoch 1904.88

ε Columbae R. A. 5ʰ 27ᵐ7 Dec. — 35° 33′

Magn. 3.9 Type K

Date	1903 Nov. 23.67	1904 Feb. 11.63	1904 Sept. 10.87	1905 Jan. 8.72	1906 Jan. 2.70
Julian day	6442.67	6522.63	6734.87	6854.72	7213.70
Plate number	60 I	180 I	410 II	530 II	864 II
Photographed by	W.	P.	P.	W.	W.
Measured by	R. H. C.	P.	P.	P.	W.
λ					
4222.382		+ 8.1		— 2.4	
31.183				+ 0.2	
33.772				0.0	
41.287				0.0	
46.968		9.0		— 0.2	+ 7.0
50.287	— 9.9			— 0.3	5.4
50.962				+ 1.2	
54.505	11.3	7.6		+ 1.1	6.7
55.134				+ 0.3	
57.815	7.4			+ 0.6	
63.290				+ 5.3	
65.374	7.8			+ 2.1	7.5
68.866	9.1				
78.390					5.0
82.565	7.7			+ 4.6	
83.169	8.4				
86.627			λ4450 central. System I	+ 3.3	
87.605	7.9	7.5		+ 2.3	7.3
91.630					8.7
4300.211	5.6				
13.034				+ 4.8	
13.771	8.6			— 0.4	5.5
16.962				+ 7.0	
18.867		10.8		+ 3.6	4.7
28.101	11.0	10.9		+ 3.5	3.2
31.795	11.4	10.2		+ 1.1	4.6
37.216	6.8	9.0		+ 0.7	4.3
37.727	9.5				
38.084	9.0				
40.634	8.5			+ 1.6	3.2
47.464				0.0	
49.150	12.1			+ 3.6	4.7
55.294				+ 1.2	
59.784	10.9			+ 1.7	5.1
66.061		13.8			
69.924					4.1
73.727				+ 6.4	
75.119	10.7			+ 0.4	
76.107	11.0	14.2		+ 2.2	4.9
79.396	10.8	11.0			3.3
88.629		11.1		— 1.8	0.0

ε Columbae (Continued)

Plate	1903 Nov. 28.67	1904 Feb. 11.68	1904 Sept. 10.87	1905 Jan. 8.72	1906 Jan. 2.70
[illegible]	6.2	14.4		— 1.3	
[illegible]				+ 2.9	
[illegible]					3.4
[illegible]				— 3.6	
[illegible]					6.5
[illegible]	[illegible]	[illegible]		— [illegible]	2.6
[illegible]					7.2
[illegible]	[illegible]				
[illegible]	[illegible]				
[illegible]	[illegible]				
[illegible]		[illegible]	Velocity variable		
[illegible]					[illegible]
[illegible]		[illegible]		— [illegible]	[illegible]
[illegible]	[illegible]				
[illegible]				— [illegible]	[illegible]
[illegible]				— [illegible]	
[illegible]		[illegible]		— [illegible]	[illegible]
[illegible]	[illegible]	[illegible]		— [illegible]	[illegible]
[illegible]	[illegible]	[illegible]			
[illegible]	[illegible]	[illegible]		— [illegible]	
[illegible]		[illegible]		— [illegible]	
[illegible]				— [illegible]	
[illegible]		[illegible]		— [illegible]	
[illegible]				— [illegible]	
[illegible]		[illegible]			
[illegible]		[illegible]			
Number of lines	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Mean	[illegible]	—10.[illegible]	—20.[illegible]	— [illegible]	— [illegible]
Curv. Corr.	[illegible]	— [illegible]	— .5	[illegible]	— [illegible]
Systematic Corr.	[illegible]	[illegible]	[illegible]	[illegible]	— [illegible]
V	[illegible]	— [illegible]	[illegible]	— [illegible]	— [illegible]
Reduction to ⊙	[illegible]	[illegible]	—[illegible]	— [illegible]	[illegible]
Observed	[illegible]	— [illegible]	— [illegible]	— [illegible]	— [illegible]

Velocity variable.

β Doradus — R. A. $5^h\ 32^m7$ Dec. — 62° 33′

Magn. 3.8 — Type F5G

Date	1903 Sept. 20.86	1903 Dec. 21.73	1904 Jan. 22.64	1904 Sept. 12.88		1904 Nov. 14.70		1904 Dec. 9.75	
Julian day	6378.86	6470.73	6502.64	6736.88		6799.70		6824.75	
Plate number	12 IV	94 II	145 I	417 IV		470 III		486 III	
Photographed by	P.	P.	P.	W.		P.		P.	
Measured by	P.	P.	P.	P.	W.	P.	W.	P.	W.
λ									
4250.287	+ 1.0								
50.962	— 1.2								
54.505	— 2.6								
82.565	+ 1.5								
4313.034	— 2.4		+26.8						
18.867	— 0.9		32.2						
25.195	— 4.2								
25.939	+ 0.4								
28.101	— 1.6	+17.1							
33.925			33.5						
38.084	— 2.2								
49.150		19.0							
55.294		18.1							
59.784	— 1.5	18.1							
75.119		21.0							
76.107	— 3.8	19.1	32.7	λ4450 central. System I.	λ4450 central. System II.	λ4450 central. System I.	λ4450 central. System II.	λ4450 central. System I.	λ4450 central. System II.
79.396	— 3.4	22.7							
83.720	— 2.9	17.6	30.4						
89.413		15.7							
99.907	+ 0.2								
4404.927	+ 1.2	17.8	32.5						
06.810		17.6							
17.857	+ 0.8	12.5	33.5						
25.608		17.6	35.0						
28.711		14.1							
30.785	+ 2.6	16.6	26.1						
35.817		20.4							
41.861	+ 3.5	17.8	30.1						
42.510	+ 0.4	22.0	29.2						
43.976		21.9							
47.302		13.5							
47.915	— 1.4	17.2	26.8						
51.752		19.2	34.2						
54.552	+ 0.4								
66.727	— 0.2		30.5						
68.647	— 0.1	20.8	36.4						
84.392		12.0	24.8						
4501.445		18.4							
08.455		20.2	31.5						
Number of lines	(24)	(26)	(17)	(26)	(30)	(35)	(35)	(46)	(29)
Mean	— 0.68	+18.00	+30.96	+16.70	+15.99	+ 1.30	+ 1.53	+12.82	+13.22
Scale Corr.	0.00	— 0.03	— 0.07	— 0.03	— 0.35	0.00	0.00	— 0.01	0.00
Systematic Corr.	— .22	— .22	— .22	.00		.00		.00	
v_s	— 0.90	+17.75	+30.67	+16.16		+ 1.42		+13.02	
Reduction to ⊙	+ 2.09	— 1.68	— 2.51	+ 2.26		— 0.03		— 1.25	
Observed V	+ 1.19	+16.07	+28.16	+18.42 wt. ½		+ 1.39 wt. ½		+11.77 wt. ½	

Velocity variable.

γ Leporis — R. A. $5^h\ 40^m.3$ Dec. $-22°\ 29'$

Magn. 3.8 — Type F8G

Date	1903 Oct. 4.84	1903 Nov. 7.73
Julian day	6392.84	6426.73
Plate Number	31 11	34 1
Photographed by	P.	W.
Measured by	R. H. C.	W.
λ		
4950.987	−28.5	−17.2
50.945	32.0	18.2
54.805	27.2	22.1
55.418		21.6
[illegible]	28.5	
[illegible]	29.0	
[illegible]		16.8
[illegible]	32.9	
[illegible]		22.9
[illegible]	33.6	
[illegible]	31.5	
[illegible]	31.8	
[illegible]	31.5	
[illegible]	29.1	
[illegible]	27.5	18.7
[illegible]	26.3	[illegible]
[illegible]		[illegible]
[illegible]		[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]		[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	
[illegible]		[illegible]
[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	
[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	
[illegible]	[illegible]	
[illegible]	[illegible]	
[illegible]		[illegible]
[illegible]		[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]		[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

[illegible]

[illegible]

β Columbae R. A. $5^h\ 47^m5$ Dec. — 35° 49′

Magn. 3.2 Type K

Date	1903 Oct. 5.84	1903 Nov. 16.82	1904 Oct. 13.82		1905 Jan. 17.66	1905 Dec. 30.74
Julian day	6393.84	6435.82	6767.82		6863.66	7210.74
Plate number	33 II	49 II	433 III		545 II	862 III
Photographed by	P.	W.	W.		W.	W.
Measured by	P.	R. H. C.	W.	P.	P.	W.
λ						
4222.382	+74.5					
33.328	78.2					
33.772	72.9					
38.970					+98.6	
41.285	76.4					
43.981					97.8	
46.968	72.4					+94.8
50.287	74.6	+79.5			97.6	93.5
50.962	73.7				97.9	
54.505					95.5	
55.134		82.4				
57.815		81.1				94.1
67.543		82.8				
68.866	74.6	87.5				
74.935					98.6	93.1
78.390			λ4450 central. System II.	λ4450 central. System I.	98.5	91.1
82.565	76.5					92.6
83.169					95.9	91.6
86.627	75.7					
87.605	73.9	82.3			98.2	94.5
4313.771	76.1	82.7			97.1	92.8
18.867	74.1				98.2	
25.195					97.5	
28.101	76.2	84.4			96.8	92.2
31.795		83.8			94.6	
37.216	71.8	84.6			96.8	92.5
37.725	73.6	84.2				93.5
38.084	75.6					
40.634		84.2			95.8	91.6
41.530	76.7					
47.464	74.4					
49.150	73.8	81.8				
55.294	77.9				98.7	
59.784	77.0				98.1	93.6
69.924					97.4	91.9
71.363					96.8	
75.119					93.7	
76.107	76.2	83.2			98.9	92.4
79.396	75.4	85.1			95.7	91.7
88.628	75.6	85.4				
89.413	79.3	83.1				

β Columbae—(Continued.)

Date	1903 Oct. 3.84	1903 Nov. 16.82	1904 Oct. 13.82		1905 Jan. 17.66	1905 Dec. 30.74
			λ4450 central, System II	λ4450 central, System I		
3966.668	77.7				97.0	
3964.558					97.1	92.9
3955.370						95.5
3966.907					96.3	93.0
4406.327					91.6	
16.537	76.8	88.1			97.1	93.0
17.550					95.8	94.0
12.340		85.3				
17.557		82.6				
18.543		82.2				
35.608		88.6				
37.444						98.4
38.711	76.4					
33.414		85.3				
35.817	77.0				94.0	95.1
41.961	74.7				94.1	91.8
42.510	74.7	85.3			97.0	95.6
42.976					98.6	
47.915	75.7				98.4	
51.752	76.9					
66.789	76.9				96.3	
68.673	75.1				99.8	
76.214					99.0	
82.376					95.4	
Number of lines	(36)	(24)	(36)	(42)	(38)	(26)
Mean	+75.50	+83.78	+73.95	+74.77	+96.77	+93.15
Scale Corr.	+ .13	— .02	+ .08	+ .02	— .44	— .18
Systematic Corr.	— .22	— .22	.00		— .22	— .22
v_s	+75.41	+83.54	+74.41		+96.11	+92.75
Reduction to ☉	+14.63	+ 7.77	+13.79		— 8.31	— 3.84
Observed V	+90.04	+91.31	+88.20		+87.80	+88.91

Mean $V = +89.25$ km.

Mean J. D. 2416730.66

Epoch 1904.69

η Columbae R. A. $5^h\ 56^m1$ Dec. — 42° 49′

Magn. 4.0 Type K

Date	1904 Jan. 10.71	1905 Jan. 4.76	1905 Jan. 16.73	1905 Dec. 12.79
Julian day	6490.71	6850.76	6862.73	7192.79
Plate number	121 I	522 II	543 II	848 III
Photographed by	P.	W.	W.	W.
Measured by	P.	P.	P.	W.
λ				
4222.382	+22.6			
38.980		+23.1		
39.525			+24.2	
46.968	23.5	22.1	24.9	+16.1
50.287		21.0	24.8	16.9
50.962		22.6	22.0	16.8
54.505		22.1	24.2	18.9
63.290			27.0	
65.374	28.1		27.2	
68.866			25.3	
74.935		23.7		15.7
76.836		26.4		
82.565			29.2	
83.169			24.9	12.9
86.627	24.0		27.2	
87.605			25.5	20.7
94.273		18.9		
4300.211			27.4	
13.771			25.0	12.1
16.962			30.6	
18.867	25.3	24.2	27.7	18.6
25.195			26.9	19.7
25.978		22.0	26.7	
28.101	21.7	20.6	24.6	14.8
31.795		26.2	24.5	18.4
32.921			26.9	
37.216		21.0	24.6	
38.854			28.6	
40.634		23.4	25.4	16.5
49.150			25.5	14.1
52.972		22.6		
55.294			25.9	
59.784	22.0		24.5	19.8
69.924		26.6		18.2
71.363		23.1		
75.119			26.6	17.6
76.107	23.8	19.4	25.4	18.0
79.396	20.8	16.3	22.9	13.9
87.007		21.5		
88.629	23.7		27.1	
89.413	25.5		24.6	

η *Columbae*—(Continued)

Date	1904 Jan. 10.71	1905 Jan. 4.76	1905 Jan. 16.73	1905 Dec. 12.79
4390.118	23.6	26.4	23.7	
91.152		20.2		17.9
95.270		22.3		17.6
99.907	23.4		26.0	
4404.927		19.2		19.8
06.810		21.3	24.0	16.3
07.850		20.9		16.0
15.312		27.8		
27.444				17.2
28.711	20.7		21.2	
30.785	23.2		21.6	
35.817	25.8		24.4	
41.861	23.3	22.8	21.4	
42.510	24.7	27.2	23.8	20.4
43.976			25.9	
47.302	18.2			
47.915	25.8	25.6	22.3	
51.752	21.8			
66.789		22.4	24.9	
68.673	26.6	23.3	27.0	
76.211		23.4	25.1	
82.376		21.6		
89.911			26.1	
4501.448	18.4			
05.003	23.7			
Number of lines	(24)	(34)	(46)	(26)
Mean	+23.34	+22.68	+25.33	+17.11
Scale Corr.	— .02	— .11	— .07	+ .01
Systematic Corr.	— .22	— .22	— .22	— .22
v_s	+23.10	+22.35	+25.04	+16.90
Reduction to ⊙	— 4.52	— 3.52	— 5.88	+ 1.43
Observed V	+18.58	+18.83	+19.16	+18.33

Mean V = +18.72 km.

Mean J. D. 2416849.25
Epoch 1905.01

δ Columbae R. A. $6^h\ 18^m4$ Dec. — 33° 23′

Magn 4.0 Type G5K

Date	1903 Dec. 5.67		1904 Feb. 8.64	1904 Sept. 26.86		1904 Nov. 2.79		1904 Dec. 18.80
Julian day	6454.67		6519.64	6750.86		6787.79		6833.80
Plate number	66 I		178 I	426 IV		456 IV		500 III
Photographed by	P.		P.	P.		P.		P.
Measured by	P.	R. H. C.	P.	W.	P.	W.	P.	P.
λ								
4187.204	—22.8							
99.267	18.2							
4202.198	24.9							
17.720	21.7							
20.509	26.6							
22.382	23.1		— 3.7					— 5.2
31.183	22.5							— 5.5
33.772	22.2							— 3.3
46.968	22.8		+ 1.5					— 3.2
50.287	23.1	—22.9						— 6.1
50.962	23.3		— 2.0					— 4.5
54.505		25.9						— 3.5
67.543		22.6						
68.866			+ 0.4					— 3.7
71.325		21.3						
82.127		20.0		λ4450 central. System II.	λ4450 central. System I.	λ4450 central. System II.	λ4450 central. System I.	
82.565	20.1	22.4						
83.169								— 4.4
86.627	20.5							
87.605		22.4						
89.525		23.8						
4313.771	22.2	21.7						
18.867			— 3.0					— 2.0
25.978	24.2							— 1.3
28.101	22.6	22.2						
31.795		22.0						+ 0.7
37.216	22.6	23.9	— 3.9					— 1.3
40.634	22.5							+ 0.5
41.530		26.6						
43.372			— 6.3					
47.464								— 0.4
55.294		25.7						
59.784		23.3	— 2.0					0.0
67.749								— 6.5
69.924	22.0							
76.107	19.9		— 3.4					— 1.5
79.396	23.8	20.9						— 3.4
83.720	20.2							+ 0.6
89.413		24.6						
90.118			+ 2.1					— 7.0
99.907								— 0.2

δ *Columbae*—(Continued)

Date	1903 Dec. 5.67		1904 Feb. 8.64	1904 Sept. 26.86		1904 Nov. 2.79		1904 Dec. 18.80
				λ4450 central. System II	λ4450 central. System I	λ4450 central. System II	λ4450 central. System I	
4404.927								— 1.0
06.810								— 4.1
16.985		22.1						
17.857		21.5						— 1.0
18.542		25.3						
25.608		20.9						
30.785			+ 0.6					— 4.6
32.736								— 0.4
33.414		22.2						
35.817	23.2							
41.861	23.3							
42.510	24.6	23.8						— 1.6
43.976	22.6	23.2						
47.915	24.1	25.1	— 1.8					— 2.8
51.752	21.9							
66.789	25.9							— 3.6
68.673	24.4		— 3.6					— 1.0
76.214			— 3.0					— 2.6
89.911			+ 2.8					
4501.445			— 3.1					
08.455			0.0					
12.906			+ 1.5					
Number of lines	(30)	(25)	(18)	(23)	(17)	(30)	(32)	(32)
Mean	—22.73	—23.05	— 1.44	—17.94	—18.38	—16.79	—17.27	— 2.47
Scale Corr.	— .13	.00	.00	— .35	+ .04	.00	.00	— .01
Systematic Corr.	— .22		— .22	.00		.00		— .22
v_s	—22.76		— 1.66	—18.32		—17.03		— 2.70
Reduction to ☉	+ 6.83		—11.05	+16.44		+13.71		+ 2.68
Observed V	—15.93		—12.71	— 1.88 wt. ½		— 3.32 wt. ½		— 0.02

Velocity variable.

α Carinae R. A. $6^h\ 21^m8$ Dec. — 52° 38′

Magn. 0.9 Type F—(Continued on p. 133)

Date	1903 Sept. 21.88	1904 Jan. 19.59	1904 Sept. 6.90	1904 Sept. 11.90	1905 Jan. 6.67
Julian day	6379.88	6499.59	6730.90	6735.90	6852.67
Plate number	15 III	138 I	403 IV	414 II	525 II
Photographed by	W.	P.	W.	W.	W.
Measured by	R. H. C.	P.	A.	P.	P.
λ					
4199.267		+20.3			
4202.198		23.2			
09.144		23.5			
16.351		24.3			
33.328		22.9			
46.968	+13.0	24.9			+22.7
50.287	12.8	22.7			15.9
50.962	11.0	23.0			20.4
54.505	13.4	22.9			22.1
60.640	12.0				17.9
71.325	12.0				
71.934	14.4				
74.935	15.7				
82.565		22.2			18.4
83.169		24.9			23.9
90.410	12.2		λ4450 central. System II	λ4450 central. System I	
94.273	13.7				
96.735	14.6				
4300.211	14.0				21.8
02.085	15.0				
03.337	14.3	24.3			22.7
13.034	16.0	23.0			20.2
16.962		21.5			
18.867					16.3
25.195	11.5	22.0			18.5
25.939	13.3	20.5			20.8
30.405	13.5				
30.866	14.2	24.9			
37.216					21.4
38.084	13.1	21.8			19.5
40.634	14.3				22.7
44.451	14.4				
75.119		19.9			19.3
76.107					23.7
83.720	13.0	21.6			21.2
85.548	13.9				
94.225	15.4				
95.242	11.4				
99.935	14.6	22.3			20.7
4404.927	14.9	23.1			20.8

a Carinae—(Continued)

Date	1903 Sept. 21.88	1904 Jan. 19.39	1904 Sept. 6.90	1904 Sept. 11.90	1905 Jan. 6.67
4415.722		22.6			
16.985	13.3				20.5
17.857	13.3	24.3			20.7
41.861					22.4
42.510		20.4	λ4450 central. System II	λ4450 central. System I	23.1
43.976	12.5	20.3			19.9
47.915		20.9			22.0
50.654	13.0				
66.727					19.6
68.623		24.7			22.0
71.017		22.4			
76.314					20.3
81.364					21.2
82.376		23.5			
4501.445		24.3			
08.455		24.9			
Number of lines	(32)	(32)	(38)	(32)	(31)
Mean	+13.62	+22.76	+13.90	+13.26	+20.73
Scale Corr.	+ .02	— .01	— .33	— .02	— .09
Systematic Corr.	— .22	— .22	.00	.00	— .22
v_0	+13.42	+22.53	+13.57	+13.24	+20.42
Reduction to ☉	+ 7.20	— 1.82	+ 6.55	+ 6.81	— 0.33
Observed V	+20.62	+20.71	+20.12 wt. ½	+20.05 wt. ½	+20.09

Mean V = +20.47 km. (including results on p. 134) Mean J. D. 2416817.58

Epoch 1904.92

a Carinae—(Continued from p. 131) R. A. $6^h\ 21^m8$ Dec. — 52° 38′

Type F

Date	1905 Jan. 6.69		1905 Jan. 6.70	1905 Jan. 6.71	1905 Nov. 9.83	1905 Nov. 24.78
Julian day	6852.69		6852.70	6852.71	7159.83	7174.78
Plate number	526 II		527 III	528 IV.	817 IV.	837 III
Photographed by	W.		W.	W.	W.	W.
Measured by	P.	A.	A.	P.	A.	P.
λ						
4238.980		+18.0	+17.3		+10.7	+14.1
39.965		20.1				
45.435		19.8				
46.968	+23.3	23.2	23.5	+23.5	15.6	17.9
47.594		20.0				
50.287	21.0	21.9	19.6	18.8	12.5	16.0
50.962	19.5	20.0	19.3	21.1	12.0	16.0
54.505	23.2	22.5	21.6	23.7	15.8	17.9
58.370		18.6	19.2		12.9	
60.640	22.7			22.1		16.6
71.325		20.6	22.2			
71.934		21.5	21.3		14.7	
74.935		24.8	23.6	22.9	18.0	16.8
78.390		18.2	18.3		12.2	
82.565	21.2	21.2	21.4	18.6	13.2	15.0
83.169	24.4	20.4				16.8
88.083		21.9	18.0		14.0	
94.273		22.8	21.9	20.8	13.3	16.7
4300.211	22.6	22.4	23.1	23.0	15.3	16.2
03.337	25.0	23.6	23.3	23.1	15.0	16.8
13.034	21.1	21.9	21.9	22.7	15.2	15.1
14.357		19.3	20.1		12.7	
18.867		17.9				
21.000		21.5	23.1	22.6	16.1	13.8
25.195	18.3	20.4	22.5	21.5	13.2	14.1
25.939	19.0	20.9	23.0	21.2		16.7
37.216	19.9	21.6				19.2
38.084	22.0	22.4		22.9	15.5	17.0
39.723		19.2				
40.634	21.3	21.7	22.4	22.4	14.8	18.1
52.012		19.0	20.6		11.6	
75.119	18.7	17.5	18.5	21.7	12.1	13.3
76.107	22.3	22.4				
83.720	21.5	21.3	20.6	22.0	14.1	17.4
87.007		21.9		23.4		18.0
91.152		24.7				19.5
95.242		19.8	18.7	19.6	13.3	13.2
99.935	21.6	22.2	21.8	21.1	14.1	14.9
4400.617		19.5			12.0	
01.611		22.5				
04.927	22.9	21.0	20.5	20.4	14.2	16.6
07.850		23.4	21.6	21.8		16.8

α *Carinae* (Continued from p. 133)

Date	1905 Jan. 6.69		1905 Jan. 6.70	1905 Jan. 6.71	1905 Nov. 9.83	1905 Nov. 24.78
4408.571		22.9				
11.940		22.0	19.6			
15.310		20.3				15.5
16.085	22.8	21.7	21.7	20.5	14.5	15.6
17.857	23.8	23.1	21.3	23.8	15.9	16.5
18.540		18.9			12.4	12.9
27.444		20.8				
35.178		18.1	19.2			
35.817		23.2				
44.861	21.6	22.8				16.7
46.510	20.7	21.5				
48.075		18.2				
49.076	20.7	21.5	21.0	20.9	13.4	14.5
[illegible]	18.8	20.1	18.2			
[illegible]		20.8		22.0	14.2	15.5
[illegible]		21.2				
[illegible]		17.6	17.1			
[illegible]		23.2	21.4			
[illegible]	22.1					
[illegible]	22.4	24.3	21.8	23.2	16.2	16.5
[illegible]	17.5			20.3		16.7
[illegible]	21.8	22.8	21.4	22.5	17.0	16.3
Number of lines	(20)	[illegible]	[illegible]	(10)	[illegible]	[illegible]
Mean	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	−16.26
Syst. Corr.	.00	.00	.08	.09	−.01	[illegible]
[illegible] Corr.		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
v		[illegible]	[illegible]	[illegible]	[illegible]	−16.00
Reduction to ⊙		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Observed		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

ν Puppis R. A. $6^h\ 34^m.7$ Dec. — 43° 6′

Magn. 3.2 Type B8A

Date	1904 Jan. 1.64	1904 Oct. 17.86	1904 Dec. 31.72	1905 Jan. 18.62	1905 Dec. 13.80
Julian day	6481.64	6771.86	6846.72	6864.62	7193.80
Plate number	104 I	440 IV	515 II	547 II	850 III
Photographed by	P.	P.	P.	W.	W.
Measured by	W.	W.	W.	W.	W.
λ					
4340.634	+31.7	+21.7	+33.7	+ 36.0	+23.3
Scale Corr.	0.0	0.0	0.0	0.0	0.0
Systematic Corr.	— .2	— .2	— .2	— .2	— .2
v_s	+31.5	+21.5	+33.5	+35.8	+23.1
Reduction to ⊙	+ 1.3	+12.0	+ 1.2	— 2.6	+ 4.8
Observed *V*	+32.8	+33.5	+34.7	+33.2	+27.9

Velocity variable.

The variation indicated by the rather small range in these determinations of radial velocity is confirmed by later plates kindly secured by Dr. Curtis. His observations are as follows:

1907 Jan. 22	+29 km.
1908 Jan. 6	+20
Jan. 14	+20

The hydrogen line, Hγ, upon the measurement of which these values depend, consists of a well defined dark line approximately in the center of a broad absorption. This appearance suggests that the spectra of both components of the system may be present.

τ Puppis R. A. $6^h\ 47^m.4$ Dec. — 50° 30′

Magn. 2.8 Type K

Date	1903 Nov. 15.74		1904 Oct. 12.82	1904 Dec. 9.82		1905 Jan. 24.68	1905 Nov. 10.81
Julian day	6434.74		6766.86	6824.82		6870.68	7160.81
Plate number	46 II		431 IV	487 IV		555 II	820 IV
Photographed by	P.		P.	P.		P.	W.
Measured by	W	R. H. C.	P.	P.	A.	P.	W.
λ							
4246.968	+32.2					+34.4	+25.9
50.287	32.8					27.8	27.0
50.962	31.1						25.7
54.505	30.4	+30.4					25.3
57.815		34.3					
67.543	29.2						
68.866						37.3	
74.935	30.1						26.2
82.127		32.9					
87.605	28.4	30.2					26.7
91.630	29.6						
4313.771	29.4	31.7					24.2
18.867	33.9						
25.195							26.0
25.978							25.7
28.101	31.1	31.4					28.6
31.795			λ4450 central. System I	λ4450 central. System I	λ4450 central. System II	30.3	
37.216	28.6	29.5				34.4	25.7
38.084		32.2					
40.634	28.6	31.1					25.4
41.530		32.8					
49.150	30.8	31.9					
59.784	31.6					34.2	27.2
75.119	29.5	31.2					
76.107	31.4	31.6				37.6	25.1
79.396		34.0				35.1	22.5
89.413		34.4					
90.118						40.1	
91.152	31.2						25.5
95.270	30.6						26.0
4406.810	30.7	30.6				35.1	24.5
07.850	33.1						27.7
11.240		35.1					
17.857		32.4					
18.542		29.6					
27.444	30.7						25.9
28.711						34.4	
35.817	27.8					37.2	25.8
41.861	34.1					30.5	
42.510	30.1					35.3	28.1

τ Puppis—(Continued)

Date	1903 Nov. 15.74		1904 Oct. 12.82	1904 Dec. 9.82		1905 Jan. 24.68	1905 Nov. 10.81
4447.915			λ4450 central. System I.	λ4450 central. System I.	λ4450 central. System II.	36.1	
66.789						29.7	
68.673						37.5	
76.214						34.6	
94.738						32.6	
Number of lines	(25)	(19)	(28)	(42)	(51)	(19)	(22)
Mean	+30.68	+31.97	+25.55	+27.52	+28.42	+34.43	+25.94
Scale Corr.	+ .19	.00	+ .02	+ .04	.00	— .15	— .04
Systematic Corr.	— .22		.00	.00		— .22	— .22
v_s	+31.20		+25.57	+27.99		+34.06	+25.68
Reduction to ⊙	+ 8.04		+ 8.84	+ 5.40		— 1.27	+ 8.22
Observed *V*	+39.24		+34.41 wt. ½	+33.39 wt. ½		+32.79	+33.90

Velocity variable.

A *Carinae* — R. A. $6^h\ 47^m6$ Dec. — 53° 31′

Magn. 4.4 — Type G5K

Date	1904 Nov. 17.74	1905 Jan. 9.79	1905 Feb. 7.69
Julian day	6802.74	6855.79	6884.69
Plate number	474 II	533 III	583 II
Photographed by	W.	W.	W.
Measured by	P.	P.	P.
λ	λ4450 central. System I.		
4246.968		+25.7	+48.8
50.287		25.1	47.9
50.962		28.2	50.1
54.505		25.0	49.0
82.565			53.1
83.169			47.3
4318.867		25.5	52.1
25.195		25.2	50.9
25.978		31.3	
28.101		28.7	53.3
31.795		26.4	51.7
37.216		26.5	
40.634		21.1	52.1
43.402			54.9
46.725		29.7	49.6
59.784		27.3	53.5
69.924		29.8	
75.119			53.5
76.107		26.2	50.7
79.396		23.1	51.3
83.720			52.0
90.118		26.5	
99.907		28.5	48.2
4404.927		24.4	45.0
06.810		24.0	49.1
17.857		25.8	
25.608			54.9
28.711			48.4
30.785			50.4
33.414		25.9	
35.817		22.3	
41.861			49.8
42.510		25.0	54.8
43.976			46.9
47.915		27.1	50.8
66.789		28.0	48.5
68.673		31.7	47.5
76.214		23.8	53.6
85.846		25.3	
Number of lines	(26)	(29)	(31)
Mean	— 5.25	+26.31	+50.64
Scale Corr.	.00	— .16	+ .10
Systematic Corr.	.00	— .22	— .22
v_s	— 5.25	+25.93	+50.52
Reduction to ⊙	+ 6.77	+ 1.24	— 2.45
Observed V	+ 1.52 wt. ½	+27.17	+48.07

Velocity variable.

σ Canis Majoris R. A. $6^h\ 57^m7$ Dec. — 27° 47′

Magn. 3.7 Type K5M

Date	1904 Oct. 16.84	1905 Jan. 18.73	1905 Feb. 18.67	1905 Dec. 13.69	1906 Feb. 3.69
Julian day	6770.84	6864.73	6895.67	7193.69	7245.69
Plate number	437 III	548 III	599 II	849 II	880 II
Photographed by	W.	W.	W.	W.	W.
Measured by	W.	P.	P.	W.	W.
λ					
4238.970		+21.5			
46.968		20.8	+33.9		
50.287		24.6	34.1		
50.962		26.6			
63.290			41.5		
65.374		21.6	33.6	+10.4	+28.2
82.565		23.1			
87.605		24.9			
4318.867		27.0	39.2		33.6
28.101		27.6	36.3	14.5	32.8
30.189			41.8		
30.866			39.8		
31.795		23.9	37.0	10.6	31.5
32.921			35.9		
37.216		24.0	32.4		
43.402			33.5		
47.464			34.9	8.8	26.1
49.150				9.0	28.6
55.294	λ4450 central. System II	26.6	33.0		
59.784		27.8	39.2	16.1	33.4
66.061		20.9			
69.924					29.4
75.119		25.3		15.0	
76.107		25.4	37.8	12.7	30.7
79.396		25.2	34.0	10.9	28.1
83.720		21.5			
88.629		24.6			
89.413			38.2		
90.143		28.9	38.2	14.2	27.2
91.152				14.1	28.6
4404.927		24.8			
06.810		26.7	37.1	10.9	24.5
07.850					25.0
11.240				13.3	
16.985		29.2			
17.857			37.1		
27.444				13.2	27.9
28.711			29.8	8.4	25.5
30.785			29.8		
41.861		25.5	34.8		
42.510		25.6	36.3	15.9	33.0

ε Canis Majoris.—(Continued.)

Date	1904 Oct. 16.84	1905 Jan. 18.73	1905 Feb. 18.67	1905 Dec. 13.69	1906 Feb. 3.69
44[illegible].015	[illegible]	22.2	34.9	13.1	29.4
80.894				12.3	26.8
8[illegible].780		25.1	35.0	12.1	33.4
8[illegible].[illegible]47		20.5	30.6	11.9	
[illegible]		21.9	34.4	9.3	
85.865		27.4			
90.6[illegible]			41.5		
Number of lines	(20)	(30)	(30)	(23)	(30)
Mean	+5.75	−24.60	−35.94	−11.92	−29.84
Scale Corr.	00	−.12	−.08	−.08	−.10
Systematic Corr.	00	−.22	−.22	−.22	−.22
V_s	+5.75	−24.82	−35.77	−11.97	−29.06
Reduction to ⊙	+26.5[illegible]	−2.86	−12.24	−9.83	−7.83
Observed V	+2[illegible] wt. ½	−2[illegible]	−25.47	−22.30	−2[illegible]

Mean V = +2[illegible] km.

Mean J. D. 2417016.9[illegible]

Epoch 1905.67

δ Canis Majoris R. A. $7^h\ 4^m3$ Dec. — 26° 14′

Magn. 2.0 Type F8G, Peculiar.

Date	1903 Dec. 13.82	1904 Oct. 18.86	1904 Nov. 18.81	1905 Nov. 19.87	1906 Jan. 31.64
Julian day	6462.82	6772.86	6803.81	7169.87	7242.64
Plate number	78 II	443 IV	477 III	829 III	875 II
Photographed by	W.	P.	W.	W.	W.
Measured by	P.	P.	P.	P.	W.
λ					
4236.089				+15.1	
50.287	+23.8			18.1	+42.3
50.945	22.7			21.3	43.4
54.505	25.3			18.6	39.7
60.640				15.0	
74.935				20.3	43.2
78.390				15.2	
82.565	22.2			15.3	39.2
83.169	23.7				40.2
4300.211					45.2
13.034				19.5	43.2
18.867	24.3			20.7	
25.195	26.4			18.0	36.9
25.939	22.4			17.5	41.1
37.216	26.7			18.2	43.9
38.084	28.6	λ4450 central. System I	λ4450 central. System I		43.6
40.634				22.9	39.7
52.949				13.6	
76.107	29.0			18.7	43.0
79.396					45.6
83.720	26.5			18.0	40.4
91.152				18.7	
95.242				18.7	39.4
99.907					44.0
4404.927	27.7			17.8	41.9
16.985				16.9	41.0
25.608	27.9				
27.444					39.9
30.785	27.5				41.3
35.817				18.4	
41.861				19.3	41.8
42.510				14.2	43.5
47.915	24.0			18.0	
66.727	24.9			14.5	
68.647				20.7	
76.214				16.0	
4501.445	27.7				
08.455	24.7				

δ Canis Majoris—(Continued)

Date	1903 Dec. 13.82	1904 Oct. 18.86	1904 Nov. 18.81	1905 Nov. 19.87	1906 Jan. 31.64
Number of lines	(19)	(37)	(27)	(28)	(24)
Mean	+25.58	+13.45	+16.81	+17.83	+41.81
Scale Corr.	+ 0.12	0.00	0.00	— 0.03	— 0.14
Systematic Corr.	— .22	.00	.00	— .22	— .22
v_s	+25.48	+13.45	+16.81	+17.58	+41.45
Reduction to ⊙	+10.07	+19.89	+16.38	+16.00	— 6.50
Observed V	+35.55	+33.34 wt. ½	+33.19 wt. ½	+33.58	+34.95

Velocity variable.

As announced in *Lick Observatory Bulletin*, **5**, p. 176, 1909, the velocity of this star is variable, the period being about 275 days. The observed range is somewhat less than five kilometers, but omitting the first three observations given below, which are separated by a considerable interval of time from the others, this is reduced to about three. These three early observations lie between one and two kilometers above the curve determined by all the rest. The cause of this discrepancy has not as yet been satisfactorily explained. All the following observations, excepting the fifth, were made at Mt. Hamilton with the Mills spectrograph.

	Date	Velocity	Photographed by	Measured by
1900	Jan. 16.83	+37.0	Wright	Burns
	March 14.68	+38.0	Wright	Burns
	April 4.67	+36.2	Wright	Burns
1905	Oct. 6.07	+32.9	Moore	Newkirk
1906	Dec. 29.77	+35.6		Paddock
1907	Jan. 21.78	+34.4	Wright	Newkirk
1908	Feb. 24.70	+32.8	Wright	Miss Hobe
	Oct. 26.03	+33.2	Albrecht	Miss Hobe
1909	Oct. 26.08	+34.6	Merrill	Miss Hobe
	Nov. 5.05	+34.9	Wright	Miss Hobe
	Nov. 27.96	+35.8	Young	Miss Hobe

γ^2 *Volantis* R. A. $7^h\ 9^m6$ Dec. — 70° 20′

Magn. 3.9 Type K

Date	1903 Dec. 22.81	1904 Oct. 27.84	1905 Jan. 27.72	1905 Nov. 23.75	1906 Feb. 7.70
Julian day	6471.81	6781.84	6873.72	7173.75	7249.70
Plate number	97 II	448 III	563 II	834 III	883 II
Photographed by	W.	W.	W.	W.	W.
Measured by	P.	P.	P.	W.	W.
λ					
4185.058	+ 5.2				
89.723	+ 4.5				
90.874	+ 5.0				
99.267	+ 4.4				
4222.382	— 1.1				
31.183	+ 0.2				
39.525			— 3.3		
41.285	— 0.8				
46.968	+ 0.6		— 1.0	— 0.6	+ 1.6
50.287	+ 1.3		— 0.2	+ 0.3	— 1.6
50.962			— 0.6	— 1.0	+ 1.9
54.505	+ 1.4		— 3.0	+ 0.6	— 2.2
57.815			— 4.3		
63.290			+ 2.7		
65.374	+ 4.9				
68.866		λ4450 central. System I	— 0.5		
74.935				+ 2.2	— 2.0
78.390				— 1.0	
82.565					+ 5.0
83.169					— 2.0
86.627	+ 1.2		— 0.2		
87.605	— 2.4			+ 2.3	
4313.771	+ 0.9		— 1.0	0.0	+ 0.3
18.867			+ 0.8	+ 2.6	— 0.2
25.195			+ 1.2	+ 3.5	+ 3.9
25.978			— 1.0	— 1.0	+ 1.1
28.101	+ 2.2		— 4.0	+ 3.5	— 1.1
30.189			+ 1.4		
37.216	+ 2.0		— 2.5	+ 0.7	
40.634			— 3.0	+ 0.7	+ 2.2
41.530				— 2.9	
49.150					+ 0.3
52.972				+ 2.0	+ 0.2
59.784	+ 0.9		— 0.4	+ 2.2	+ 2.2
69.924				— 1.5	+ 2.2
75.119			+ 1.0		0.0
76.107	— 1.5		— 0.2	+ 3.4	+ 1.1
79.396	— 2.5		— 3.8	+ 2.5	— 3.5
83.720				— 0.8	
88.629			— 1.3		
89.413			— 2.9		

γ^2 *Volantis*— Continued.

Date	1903 Dec. 22.81	1904 Oct. 27.84	1905 Jan. 27.72	1905 Nov. 23.75	1906 Feb. 7.70
4390.118	— 3.1				
91.152				— 3.4	— 1.1
95.270				+ 1.4	— 3.2
99.907	— 2.6		— 1.2		
4406.810	+ 2.5		— 2.0	— 3.9	— 0.4
07.850		λ4450 central. System I		— 1.2	+ 1.9
17.857	+ 2.4				
27.444				0.0	— 1.2
28.711	— 3.4		— 3.8		
30.785	— 0.8			— 0.4	
35.817	+ 0.3			— 0.8	
41.861	— 3.0		— 3.2	+ 2.0	0.0
42.510	— 0.2		+ 0.2	+ 1.2	— 0.8
47.915	+ 1.5		— 4.0		
51.752	— 1.0				
55.485	+ 3.5				
68.673	0.0		— 2.9		
76.214			— 4.0		
Number of lines	(32)	(36)	(31)	(30)	(27)
Mean	+ 0.70	+ 3.23	— 1.51	+ 1.02	+ 0.17
Scale Corr.	.00	.00	.00	.00	.00
Systematic Corr.	— .22	.00	— .22	— .22	— .22
v_s	+ 0.48	+ 3.23	— 1.73	+ 0.80	— 0.05
Reduction to ☉	+ 3.01	— 0.17	+ 3.82	+ 1.59	+ 3.76
Observed V	+ 3.49	+ 3.06 wt. ½	+ 2.09	+ 2.39	+ 3.71

Mean $V = +2.94$ km.

Mean J. D. 2416924.42
Epoch 1905.21

ω Canis Majoris R. A. 7^h 10^m7 Dec. — 26° 35′

Magn. 3.8 Type B3A Peculiar

Date	1904 Jan. 1.78	1904 Dec. 19.81	1905 Dec. 15.75
Julian day	6481.78	6834.81	7195.75
Plate number	106 III	502 III	855 III
Photographed by	P.	W.	W.
Measured by	W.	W.	W.
λ			
4340.634	+30	+30	+14
4388.100	+38	+25	
4471.693	+24		
Mean	+30.7	+27.5	+14
Scale Corr.	——	——	——
Systematic Corr.	— .2	— .2	— .2
v_s	+30.5	+27.3	+13.8
Reduction to ⊙	+ 4.7	+ 8.6	+10.1
Observed V	+35	+36	+24

Mean V = +32 km. Mean J. D. 2416837.45

Epoch 1904.97

The hydrogen lines in this star are bright on a dark background. The breadth of the bright Hγ line, as measured on two of the plates, is as follows:

Plate number	Breadth of Hγ line
502 III	1.7 Angstrom's
855 III	2.5 Angstrom's

It cannot be said whether the difference here shown is real, or an effect of difference in density between the two photographs. The distance between the centers of the dark bands on either side of the bright line, as measured on plate 106 III, is about 3.5 Angstrom's. The character of this line appears to vary greatly on the different spectrograms. On plate 855 III there seems to be a dark line in the center of the bright Hγ. The position of the bright line with reference to the broad dark line on which it is superposed seems to vary, though it is impossible to make a positive statement to this effect on account of the small number of plates and the diffuse character of the line. On one plate, secured November 10, 1904, but not referred to in the table, the line is perceptible only as a narrow and inconspicuous maximum, the measurement of which yields a velocity of +69 km. This result has not been included in the table on account of the uncertainty as to just what was being measured.

The measurements on which the tabular velocities for Hγ depend were made on the center of the Hγ bright line.

δ Volantis R. A. $7^h\ 16^m9$ Dec. — 67° 47′

Magn. 4.0 Type F5G

Date	1904 Feb. 6.68	1904 Nov. 6.82		1905 Dec. 15.67	1906 Feb. 8.69
Julian day	6517.68	6791.82		7195.67	7250.69
Plate number	171 I	458 III		854 II	885 IV
Photographed by	W.	P.		W.	W.
Measured by	W.	W.	P.	W.	W.
λ		λ4450 central. System II	λ4450 central. System I		
4246.968				+20.9	
50.287				17.8	+18.8
50.945				18.4	22.8
54.505	+16.0			20.5	25.0
74.935	20.3			19.6	21.6
78.390				16.2	20.8
82.565				18.9	21.9
83.169				17.6	18.3
4303.337				21.6	
13.034	18.3			19.0	22.8
20.990	20.6				
25.195				15.8	19.0
25.939				20.7	22.5
31.795				15.2	
37.216				22.1	
38.084				17.5	
76.107	23.6			14.2	19.8
83.720	18.9			19.7	16.6
91.152					19.0
95.242	21.8			21.4	18.8
4404.927	22.5			18.2	20.6
07.850					20.3
17.857				19.7	
27.444	18.8			16.0	18.4
35.817				22.6	18.9
41.861				22.3	17.9
42.510				20.4	22.4
Number of lines	(9)	(32)	(33)	(24)	(20)
Mean	+20.09	+19.02	+18.54	+19.05	+20.31
Scale Corr.	+ 0.08	+ 0.01	— 0.01	— 0.06	— 0.05
Systematic Corr.	— .22	.00		— .22	— .22
v_s	+19.95	+18.78		+18.77	+20.04
Reduction to ⊙	+ 3.44	+ 1.82		+ 3.70	+ 3.32
Observed V	+23.39	+20.60 wt. ½		+22.47	+23.36

Mean $V = +22.72$ km. Mean J. D. 2416938.96

Epoch 1905.25

η Canis Majoris R. A. $7^h\ 20^m2$ Dec. — 29° 7′

Magn. 2.4 Type B5A, Peculiar.

Date	1904 Jan. 21.59	1904 Dec. 20.82	1905 Jan. 26.61		1905 Dec. 14.85
Julian day	6501.59	6835.82	6872.61		7194.85
Plate number	142 I	504 III	559 II		853 IV
Photographed by	P.	W.	W.		W.
Measured by	P.	P.	W.	P.	W.
λ					
4267.280		+34	+48	+49	
4340.634	+47	+17	+24	+26	+31
88.100	+40	+35	+49	+47	+25
4471.693	+45	+26	+41	+44	+31
81.375	+40	+21	+44	+43	+22
Number of lines	(4)	(5)	(5)		(4)
Mean	+43.0	+26.6	+41.2	+41.8	+27.2
Scale Corr.	.0	.0	.0		.0
Systematic Corr.	— .2	— .2	— .2		— .2
v_s	+42.8	+26.4	+41.3		+27.0
Reduction to ☉	— 0.6	+ 9.2	— 2.5		+10.9
Observed V	+42	+36	+39		+38

Mean V = +39 km. Mean J. D. 2416851.22

Epoch 1905.01

The agreement among the mean velocities for the different plates is as good as can be expected in the case of a spectrum containing such hazy lines. There appears, however, to be evidence of a shift of the Hγ line (λ4340.6) with reference to the others.

σ Puppis R. A. $7^h\ 26^m.1$ Dec. — 43° 6′

Magn. 3.3 Type K5M

Date	1904 Jan. 15.75	1904 Jan. 29.74	1904 Oct. 25.81	1904 Dec. 22.80
Julian day	6495.75	6509.74	6779.81	6837.80
Plate number	133 II	158 I	446 III	506 III
Photographed by	P.	W.	P.	P.
Measured by	P.	R. H. C.	P.	P.
λ				
4246.968				+92.3
50.287				96.5
50.962				95.1
65.374				87.7
68.866				95.1
4313.771				95.8
18.867				95.3
28.101	+84.2	+92.4		96.8
37.216				97.4
40.634		91.6		
41.530		83.6		
43.372	74.5			
47.464				94.1
49.150				91.2
59.784		96.6	λ4450 central. System 1	95.8
69.924	82.5			94.0
76.107				97.5
79.396	86.8	92.9		93.9
88.629				100.0
90.143				97.6
4406.810	79.4	88.4		97.6
11.240		91.2		
15.722		87.9		
28.711	81.6			94.2
35.817		86.7		
41.861				93.3
42.510	84.0	87.3		93.4
43.976		89.4		
47.915	79.4			95.2
55.485	75.3			
66.789	88.2			98.3
68.745	80.7			96.1
85.846	89.4			
89.911	92.7			
4501.445	82.8			
05.003	83.6			
12.906	80.2			
Number of lines	(16)	(11)	(32)	(24)
Mean	+82.83	+89.82	+83.57	+ 95.18
Scale Corr.	— .11	— .18	+ .03	+ .02
Systematic Corr.	— .22	— .22	.00	— .22
v_s	+82.50	+89.42	+83.60	+ 94.98
Reduction to ⊙	+ 2.87	— 0.42	+13.35	+ 7.81
Observed V	+85.37	+89.00	+96.95 wt. ½	+102.79

Velocity variable.

A. G. C. 9664 R. A. $7^h\ 26^m9$ Dec. — 30° 45′

Magn. 4.8 Type G

Date	1904 Mar. 15.65	1905 Jan. 17.79	1905 Feb. 5.74	1905 Dec. 28.80
Julian day	6555.65	6863.79	6882.74	7208.80
Plate number	246 I	546 III	581 II	860 III
Photographed by	W.	W.	P.	W.
Measured by	P.	P.	A.	W.
λ				
4243.981		+11.9		
46.968	+25.5	15.4		
50.287	25.4	10.8	+18.0	+ 7.3
50.962	27.5	13.6		9.2
54.505		15.5	17.3	6.4
74.935			18.0	9.5
76.836		11.7		
78.390	24.2		15.5	
82.565	29.1	12.6		7.6
83.169	29.0			7.3
88.133			19.5	
91.630		15.5		
92.303			20.4	
94.273	28.1			
4313.034	31.8	13.3		9.0
18.867	28.7		18.6	9.2
21.000	30.1		18.9	
25.195		11.8		5.3
25.978	29.7	12.4		1.8
28.101	34.3	12.2	19.9	6.7
31.795			23.3	7.4
37.216		15.0		8.6
38.084				5.4
46.725		13.4		
52.949	34.2		16.9	
59.784		17.2	19.6	8.1
69.924	27.3			
71.363	28.4		19.7	
76.107	31.2	14.0	15.8	5.2
79.396		13.5	14.7	
83.720	27.5	13.2		3.8
85.144	27.1			
87.007			19.4	
88.629		12.3		
90.118			17.8	
91.146				5.3
95.270				2.2
99.907	31.1	13.3		3.9
4404.927	31.6	15.9		8.1
06.810		13.3		7.0
07.850				2.7

A. G. C. 9664—(Continued)

Date	1904 Mar. 15.65	1905 Jan. 17.79	1905 Feb. 5.74	1905 Dec. 28.80
4416.985	31.9	12.8	19.7	
17.857	32.1	13.0		7.5
25.608	35.8	17.5		
27.444			19.0	5.6
30.785		12.1		
35.817		12.4		6.0
41.861		13.3		10.2
42.510	35.4	13.6	21.0	7.7
43.976		15.0	21.0	11.8
44.728		12.2		
47.915	27.1	14.4	20.8	
66.727	33.7	14.8		
68.647	32.6	13.2	21.3	
76.214	33.2	13.9		
85.846	27.2			
Number of lines	(29)	(35)	(23)	(29)
Mean	+30.03	+13.60	+18.96	+ 6.75
Scale Corr.	— .02	— .01	— .01	— .02
Systematic Corr.	— .22	— .22	— .22	— .22
v_s	+29.79	+13.37	+18.73	+ 6.51
Reduction to ⊙	—14.99	+ 1.03	— 5.06	+ 7.50
Observed V	+14.80	+14.40	+13.67	+14.01

Mean V = +14.22 km.

Mean J. D. 2416877.75
Epoch 1905.08

c *Puppis* — R. A. $7^h\ 41^m7$ Dec. — 37° 44′

Magn. 3.7 — Type K5M

Date	1903 Dec. 21.82	1905 Feb. 3.76	1906 Jan. 27.76	1906 Feb. 18.68
Julian day	6470.82	6880.76	7238.76	7260.68
Plate number	95 III	580 III	874 III	888 II
Photographed by	P.	P.	W.	W.
Measured by	P.	W.	W.	W.
λ				
4313.034	+ 2.4			
18.867	13.1	+21.4		+23.8
21.000	3.3			
28.101	10.5	22.6	+17.6	22.9
31.795	7.7		19.1	24.8
46.725	13.3			
49.150		15.9	17.4	
52.990	8.9	18.3	18.7	25.3
59.784		23.5	22.0	28.6
69.924	8.8	17.5	19.3	26.4
71.363	6.8			
75.119	10.9			
76.107	8.3	18.7	17.6	
79.396	5.4	19.5	18.7	22.9
90.143	9.5			
91.152	3.3	17.9	22.8	21.7
95.298		21.0		26.4
4406.810	12.9			23.3
07.850	5.5	16.8		21.4
18.542	7.6			
27.444		18.0	16.0	23.5
28.711		15.2		
41.861	8.2		17.9	
42.510	10.4	19.9	17.1	24.4
47.915	7.8	13.5	14.7	23.7
59.324		20.1	17.2	22.2
66.789	6.5			
68.745	5.4			
76.211	7.2			
82.376	3.5			
85.846	11.2			
Number of lines	(25)	(16)	(14)	(15)
Mean	+ 7.94	+18.73	+18.30	+24.09
Scale Corr.	— .01	— .04	— .05	— .05
Systematic Corr.	— .22	— .22	— .22	— .22
v_s	+ 7.71	+18.47	+18.03	+23.82
Reduction to ⊙	+10.30	— 1.53	+ 0.55	— 5.47
Observed V	+18.01	+16.94	+18.58	+18.35

Mean V = +17.97 km. — Mean J. D. 2416962.76

Epoch 1905.32

ζ Volantis R. A. $7^h\ 43^m0$ Dec. — 72° 22′

Magn. 3.9 Type K

Date	1904 Jan. 20.79	1904 Mar. 14.63	1905 Feb. 9.75	1906 Jan. 31.74
Julian day	6500.79	6554.63	6886.75	7242.74
Plate number	141 II	244 I	589 III	876 III
Photographed by	P.	W.	W.	W.
Measured by	P.	P.	P.	W.
λ				
4222.382	+47.1			
38.980		+45.9		
46.968	45.7	47.0	+41.7	+45.5
50.287	41.1	45.3	41.4	43.9
50.962	46.0	45.2	44.3	44.2
54.505	46.7	43.3	43.9	46.2
58.500		46.0		
68.866	46.2		46.5	
74.935		47.3		44.9
78.390		45.6		44.6
86.627			49.3	
87.605			43.9	48.1
94.273		43.5		
4313.034		43.8		
13.771	46.5		45.4	41.5
18.867	43.7	44.3	44.6	43.3
25.195	43.6		45.1	46.3
25.978		43.4		47.2
28.101	44.2	41.8	44.4	
31.795	45.2		42.5	45.0
37.216		49.4	40.0	47.1
37.725			41.3	
40.634	44.6	47.0	43.0	43.3
49.150				42.7
52.972		46.2		43.9
55.294			44.0	
59.784	46.2		43.4	43.7
76.107	43.8	44.0	45.4	42.6
79.396	39.1	44.9	40.2	45.5
83.720		43.6		
89.413	44.5		47.0	
90.118	41.1		43.7	
91.152				44.2
95.270		43.1		45.2
99.907	40.9		42.2	
4404.927		42.3		
06.810	41.6	41.6	43.9	45.5
07.850		40.3		46.0
15.312		48.8		
25.608			47.2	
27.444				41.9

ζ Volantis—(Continued)

Date	1904 Jan. 20.79	1904 Mar. 14.63	1905 Feb. 9.75	1906 Jan. 31.74
4428.711			41.6	
30.785	42.4		41.8	
35.817			42.9	
38.006	40.8		39.2	
41.861	40.9	38.5	45.8	
42.510	43.0	44.7	43.6	47.6
43.976	45.1		45.5	
47.915	44.3	43.1	43.1	
51.752			43.5	
66.789	39.3	46.7	42.7	
68.673	46.0	44.5	41.6	
76.214		47.6	42.4	
81.364			47.1	
4501.445	42.5			
Number of lines	(28)	(30)	(37)	(25)
Mean	+43.65	+44.62	+43.65	+44.86
Scale Corr.	— .06	— .01	— .03	— .17
Systematic Corr.	— .22	— .22	— .22	— .22
v_s	+43.37	+44.39	+43.40	+44.47
Reduction to ⊙	+ 5.30	+ 4.24	+ 5.44	+ 5.49
Observed V	+48.67	+48.63	+48.84	+49.96

Mean V = +49.02 km.

Mean J. D. 2416796.23
Epoch 1904.86

ξ *Puppis* R. A. 7h 45m.1 Dec. — 24° 37′

Magn. 3.5 Type G

Date	1903 Nov. 11.87	1904 Nov. 9.80	1905 Feb. 1.63	1905 Dec. 20.83	1906 Feb. 23.66
Julian day	6430.87	6794.80	6878.63	7200.83	7265.66
Plate number	43 IV	462 III	575 II	858 IV	893 III
Photographed by	P.	P.	W.	W.	C.
Measured by	P.	A.	P.	W.	W.
λ					
4240.308	−19.7		−11.2		
50.287	17.0		4.6	— 9.2	
50.462	14.3		8.3	9.2	−18.1
54.505	18.9		7.8	9.9	19.9
57.815	14.8				
65.374	15.5		6.2		
68.866	17.1		10.4		
74.935				8.9	
78.390				8.9	15.5
82.565	18.7		8.8	7.0	
83.169	19.9		8.1	9.0	17.6
87.605	17.7				15.0
4313.034			9.5	6.9	15.9
16.962	15.0				
18.867				4.4	20.3
25.195	21.1			12.6	
25.978			10.8	9.5	
28.101	19.6		10.7	8.5	15.2
31.795	17.1		8.9		16.6
32.921			7.6		
37.216	18.0		6.4	7.5	
43.402	15.0				
46.725			9.6		
47.403	11.6				
49.150	14.4		9.4	8.7	
55.294	16.3		8.7		
59.784	12.0			6.2	15.8
76.107	14.2		9.3	8.6	17.6
79.396	19.3		6.8	8.3	11.9
83.720			8.9	7.6	
88.629	17.3			9.9	
89.413	14.0		10.1		
90.118	13.3		11.5		
91.152				9.2	15.2
95.270				10.8	14.4
99.907			7.5		
4404.927			9.3	4.7	
06.810	16.1		5.8	11.3	10.1
07.850				8.2	14.0
17.857			10.7	7.9	
27.444				7.2	17.6

λ4400 central. System II

ξ Puppis—(Continued)

Date	1903 Nov. 11.85	1904 Nov. 9.80	1905 Feb. 1.63	1905 Dec. 20.83	1906 Feb. 23.68
4428.711	18.7		5.8	12.0	
30.785	16.2				
35.817	15.6	λ4450 central. System II	8.9		
41.861	16.7		5.6	6.9	14.2
42.510	15.5		5.3	9.8	13.4
43.976			9.6		
44.728	15.6				
47.915	13.7		7.0		
51.752	18.7				
66.789	17.4		7.1		
68.647	12.9		8.5		
76.214	17.5		6.8		
85.846			10.6		
Number of lines	(37)	(38)	(36)	(29)	(19)
Mean	—16.03	—18.73	+ 8.39	— 8.58	+15.22
Scale Corr.	— .01	.00	+ .01	+ .01	— .04
Systematic Corr.	— .22	.00	— .22	— .22	— .22
v_s	—16.26	—18.73	+ 8.18	— 8.79	+14.96
Reduction to ⊙	+20.65	+20.84	— 2.71	+12.30	—10.56
Observed V	+ 4.39	+ 2.11 wt. ½	+ 5.47	+ 3.51	+ 4.40

Mean V = +4.18 km.

Mean J. D. 2416927.42
Epoch 1905.22

α *Puppis* — R. A. 7h 48m.8 Dec. — 40° 19′

Magn. 3.8 — Type G5K

Date	1904 Jan. 3.80	1904 Nov. 8.79	1904 Dec. 10.76	1905 Feb. 23.64	1905 Oct. 31.84
Julian day	6483.80	6793.79	6825.76	6900.64	7150.84
Plate number	113 IV	460 III	490 III	608 II	808 II
Photographed by	P.	P.	P.	W.	W.
Measured by	P.	P.	P.	P.	W.
λ					
4222.382	−17.9				
25.619	24.2				
33.772	18.4				
46.468	20.6			−21.8	− 6.1
50.287	19.5			22.4	4.8
50.962				19.3	1.9
54.505				18.8	2.9
65.374				26.1	
68.866	22.0			20.1	
74.935					2.7
86.627				24.2	
87.605				23.5	
91.630					3.7
4313.771				24.5	
16.962				23.8	
18.867				21.7	
25.195				20.8	3.9
28.101				21.5	3.9
32.795	21.6			19.2	
37.216				19.0	0.7
40.634	18.6			19.0	4.7
41.530		λ4460 central. System I	λ4460 central. System I	22.4	
49.150				21.4	
55.294				21.5	
59.784	19.4			21.3	3.3
75.119				18.3	
76.707	18.7			20.9	4.1
79.396	23.8			19.6	7.3
88.629				21.3	
89.413	19.6			20.2	
90.118				18.1	
91.152					2.7
99.307	19.0			19.7	
4404.927					1.4
06.810				20.1	
07.850					2.0
27.444					4.4
28.711				16.0	
30.785				18.0	
33.414	23.0				
35.817	18.1			21.2	

a *Puppis*—(Continued)

Date	1904 Jan. 3.80	1904 Nov. 8.79	1904 Dec. 10.76	1905 Feb. 23.64	1905 Oct. 31.84
4438.006	13.8			15.8	
41.861	17.8			18.4	
42.510				19.5	3.7
47.915	16.7			20.8	
51.752		λ4450 central. System I.	λ4450 central. System I.	20.5	
66.789				17.1	
68.673	22.0			20.7	
76.214				18.1	
85.846	23.4				
Number of lines	(20)	(23)	(32)	(39)	(18)
Mean	+19.40	+ 1.91	+ 3.61	+20.43	— 3.51
Scale Corr.	— .03	.00	.00	+ .02	.00
Systematic Corr.	— .22	00	00	— .22	— .22
v_s	+19.15	+ 1.91	+ 3.61	+20.23	— 3.73
Reduction to ☉	+ 7.81	+15.30	+12.52	— 5.36	+15.21
Observed V	+26.96	+17.21 wt. ½	+16.13 wt. ½	+14.87	+11.48

Velocity variable.

B *Carinae* — R. A. $8^h\ 7^m3$ Dec. — 60° 59′

Magn. 4.8 — Type F5G

Date	1904 Jan. 20.65	1904 Mar. 10.64	1905 Feb. 1.77	1905 Apr. 6.58
Julian day	6500.65	6550.64	6878.77	6942.58
Plate number	140 I	231 I	576 III	686 III
Photographed by	P.	P.	W.	W.
Measured by	P.	W.	P.	P.
λ				
4246.968	+16.2		+18.4	+26.0
50.287	14.3		15.3	25.4
50.945	19.9		20.5	29.5
54.505	17.1		14.4	25.6
60.640		+27.8		27.7
71.325		23.6		
71.934		22.4		
74.935			19.6	
82.565	18.4		14.6	23.7
83.169			19.6	25.6
90.410			21.0	
4300.211			15.5	26.2
13.034	16.9	23.6	23.0	28.4
25.939	24.2	24.9	17.6	27.1
37.216			14.8	
38.084			16.8	
40.634			20.9	33.8
59.784		24.5	16.5	33.1
76.107	19.1	25.6	17.8	
83.720	20.6	25.8	16.3	27.2
91.152			17.4	
95.242	21.9	24.1	20.2	
99.907			18.1	25.3
4404.927	24.3	27.5	17.5	25.8
07.850	17.0			
16.985			17.5	
17.857		25.4	17.1	27.2
30.785				25.8
42.510			18.7	25.2
43.976	27.5	30.4	18.3	31.6
50.654	22.0		17.0	
66.727	15.8		21.7	24.0
68.647	22.7	26.3	19.5	27.8
76.214	17.4		18.4	26.8
81.375		28.9	16.3	29.8
Number of lines	(17)	(14)	(30)	(23)
Mean	+19.72	+25.76	+18.02	+27.33
Scale Corr.	— .02	.00	— .05	+ .03
Systematic Corr.	— .22	— .22	— .22	— .22
V_s	+19.48	+25.54	+17.75	+27.14
Reduction to ⊙	+ 6.36	+ 0.47	+ 5.00	— 3.02
Observed V	+25.84	+26.01	+22.75	+24.12

Mean V = +24.68 km.

Mean J. D. 2416718.16
Epoch 1904.65

ε Carinae R. A. $8^h\ 20^m.4$ Dec. — 59° 11′

Magn. 1.7 Type K Comp.

Date	1903 Nov. 8.86	1904 Nov. 13.80	1905 Feb. 3.62	1905 Nov. 20.83
Julian day	6427.86	6798.80	6880.62	7170.83
Plate number	37 I	468 IV	579 II	832 IV
Photographed by	W.	P.	P.	W.
Measured by	R. H. C.	W.	P.	P.
λ				
4238.980				+ 2.7
41.287			+ 3.4	
46.968			5.0	2.1
50.287			8.1	3.5
50.962			7.6	
63.290			11.8	
65.374	+ 2.6		3.1	
68.866			7.0	
78.390				4.5
87.605	+ 2.3		8.0	
4313.771			8.5	
18.867			6.9	4.2
25.195			4.5	
25.978			2.9	
28.101	— 1.9		7.0	3.7
30.189		λ4450 central. System II	8.8	
30.866			9.7	
31.795	+ 6.5		4.6	1.9
37.216			4.1	3.9
47.464			5.0	
49.150	+ 2.4		9.2	
52.972				5.0
55.294	+ 0.3			2.7
59.784			12.7	
69.924				3.2
71.363				2.6
75.119			5.8	
76.107	+ 1.9		6.5	3.6
79.396	+ 4.9		6.3	0.5
88.629	+ 3.2			
89.413	+ 5.0		8.0	
90.118			8.2	
91.152				4.0
95.270				5.2
4406.810	+ 3.9		3.7	+ 1.2
07.850				— 0.4
18.542	+ 5.6			
28.711			2.4	
32.736			9.0	
41.861			6.0	
42.510	+ 5.5		7.5	+ 1.2

ε *Carinae*—(Continued)

Date	1903 Nov. 8.86	1904 Nov. 13.80	1905 Feb. 3.62	1905 Nov. 20.83
4447.915		λ4450 central. System II.	6.8	6.2
51.752			5.9	
66.789			6.0	2.5
68.673			7.1	5.7
76.214			3.6	1.9
82.376				2.6
Number of lines	(13)	(27)	(35)	(24)
Mean	+ 3.25	+ 0.78	+ 6.59	+ 3.09
Scale Corr.	.00	.00	.00	— .01
Systematic Corr.	— .22	.00	— .22	— .22
v_s	+ 3.03	+ 0.78	+ 6.37	+ 2.86
Reduction to ☉	+ 7.37	+ 7.90	+ 5.56	+ 8.33
Observed V	+10.40	+ 8.68 wt. ½	+11.93	+11.19

Mean V = +10.82 km.

Mean J. D. 2416822.49
Epoch 1904.93

β Volantis R. A. 8ʰ 24ᵐ7 Dec. — 65° 48′

Magn. 3.6 Type K

Date	1904 Jan. 14.82	1904 Mar. 11.63	1905 Jan. 22.76	1905 Apr. 8.60
Julian day	6494.82	6551.63	6868.76	6944.60
Plate number	131 III	235 I	554 IV	688 II
Photographed by	P.	P.	P.	W.
Measured by	P.	P.	A.	P.
λ				
4199.267	+25.5			
4211.127	15.1			
17.720	21.7			
31.183	21.7			
33.772	20.3			
38.980		+28.2	+19.9	+23.6
39.525				23.9
39.965			15.9	
45.435			17.5	
46.968	19.0	26.1	18.5	27.1
50.287	23.5	23.5		25.0
50.962				24.1
54.505				24.5
57.815				25.1
58.500		25.7		
63.290	23.5			31.1
65.374	26.9			29.7
68.866			18.7	27.7
74.935		22.3		
78.390		23.8		
82.565				27.7
86.627				30.0
87.605	25.4	25.0		29.0
88.162		27.0	19.4	
93.239			19.1	
94.273		23.0		
4313.034		24.5		
13.771		27.9		27.1
14.357			20.0	
16.962				33.1
18.867	24.4	25.7	19.6	29.6
21.898			21.3	
25.195				26.8
25.978				27.9
28.101	22.1	26.5	20.2	28.7
30.189				29.0
30.866				31.9
31.795			16.8	27.1
34.101			19.5	
35.000			19.8	
37.216	22.0	19.7		27.9
37.725				26.0
39.723			18.7	
40.634	21.2	25.4		26.1
41.167				29.2
41.530				28.8
44.625			18.5	
49.150			20.9	29.3
52.972		24.5	21.0	
55.294		27.7		24.2

β Volantis—(Continued)

Date	1904 Jan. 14.82	1904 Mar. 11.63	1905 Jan. 22.76	1905 Apr. 8.60
4359.784			19.7	28.9
69.924	18.4	24.2		
71.363		24.5	19.6	
75.119			21.1	27.3
76.107	21.4	25.6	19.6	26.4
79.396	20.2	20.9	18.9	25.9
89.413				29.6
90.118	23.4	24.0	19.5	24.3
91.152		20.6		
95.270			19.8	
99.907	19.9	24.5		26.0
4400.675			18.8	
01.611			20.4	
06.810	15.7	24.7	20.7	28.1
07.850		19.1		
08.571			18.3	
11.240			23.9	
15.312		26.8		
27.444			18.6	
28.711				25.2
30.785	15.1	20.5		23.2
33.414				
34.060		24.0	22.8	
35.214			18.8	
35.817	20.4			26.4
38.006				21.4
41.861	18.0	20.9	18.1	26.7
42.510	20.8	25.8	20.5	28.0
43.976				26.5
47.915	20.4	24.7	18.6	26.6
57.656			23.3	
59.324			19.1	
60.486			22.8	
66.789	22.7	27.3	15.7	
68.673		28.3	20.2	30.1
76.214	21.1	27.4		23.8
82.376		26.0		
85.846		22.7		
89.911	21.2			
4501.445	16.9			
05.003	17.3			
12.906	20.8			
Number of lines	(31)	(37)	(41)	(48)
Mean	+20.84	+24.56	+19.61	+27.14
Scale Corr.	— .01	+ .01	— .07	+ .04
Systematic Corr.	— .22	— .22	— .22	— .22
v_s	+20.61	+24.35	+19.32	+26.96
Reduction to ⊙	+ 7.34	+ 2.94	+ 7.10	— 0.57
Observed V	+27.95	+27.29	+26.42	+26.39

Mean V = +27.01 km.

Mean J. D. 2416714.95
Epoch 1904.64

β Pyxidis R. A. $8^h\ 36^m2$ Dec. — 34° 57′

Magn. 4.0 Type G5K

Date	1903 Nov. 15.83	1904 Mar. 13.64	1905 Feb. 10.61	1905 Apr. 15.58
Julian day	6434.83	6553.64	6887.61	6951.58
Plate number	47 III	241 I	591 III	694 II
Photographed by	P.	P.	W.	P.
Measured by	P.	P.	P.	W.
λ				
4222.382	—31.2			
38.980		— 7.5		
46.968	30.6	6.0	—15.7	— 0.9
50.287	31.7	6.4	19.3	
50.962		4.9	15.7	+ 3.2
54.505	33.4	7.3	18.4	+ 0.6
68.866			13.6	
74.935		7.4		— 1.4
76.836			16.6	
78.390		9.3		
82.565			14.3	
87.605			18.2	
94.273		6.0		
4313.034	33.4	10.2	17.8	+ 5.2
13.771	34.4			
18.867			14.9	+ 1.7
21.000		10.1		
25.195	35.4	9.0	16.8	+ 1.1
25.978		5.4	16.8	— 0.3
28.101	33.3	12.5	14.8	
30.866	29.2		12.4	
31.795	33.6		13.9	+ 1.1
37.216	32.0	6.3	16.4	— 0.4
52.949		3.1		
59.784	33.7		16.4	+ 1.8
69.924	36.9	12.2		
71.363		7.0		
75.119			15.7	
76.107	34.2	8.4	11.8	+ 3.0
83.720		8.2	14.2	
89.413	35.1		16.6	
90.118	34.3			
91.152		7.9		+ 0.4
95.270		5.5		— 1.7
99.907	31.9	11.6	18.2	
4404.927		5.6	14.0	+ 0.8
06.810	29.4	7.4	20.3	— 3.1
07.850		12.4		
17.857	31.6	12.7	19.7	
27.444				— 0.8
30.785	31.7		15.8	

β Pyxidis—(Continued)

Date	1903 Nov. 15.83	1904 Mar. 13.64	1905 Feb. 10.61	1905 Apr. 15.58
4435.817	28.4		19.2	— 0.8
41.861	33.8		19.4	
42.510	30.2	4.3	17.3	+ 4.1
43.976	31.2	10.1	17.3	
47.915	31.9	6.7	14.9	
51.752	29.0			
66.789		7.2	16.7	
68.673	31.4	10.8	14.6	
76.214	28.8	8.3	18.6	
82.376		5.7		
4501.445	31.3		20.8	
08.455	34.5			
Number of lines	(30)	(33)	(35)	(19)
Mean	—32.26	— 7.98	—16.49	+ 0.75
Scale Corr.	— .02	.00	.00	.00
Systematic Corr.	— .22	— .22	— .22	— .22
v_s	—32.50	— 8.20	—16.71	+ 0.53
Reduction to ⊙	+19.00	— 8.58	+ 1.56	—16.12
Observed V	—13.50	—16.78	—15.15	—15.59

Mean V = —15.26 km.

Mean J. D. 2416706.92
Epoch 1904.62

b *Velorum* R. A. $8^h\ 37^m3$ Dec. — 46° 17′

Magn. 4.1 Type F5G, Pec.

Date	1903 Nov. 17.81	1905 Jan. 19.68	1905 Mar. 7.69	1905 Apr. 24.58	1906 Jan. 5.74
Julian day	6436.81	6865.68	6912.69	6960.58	7216.74
Plate number	51 III	550 II	619 IV	711 II	868 II
Photographed by	W.	W.	W.	W.	W.
Measured by	A.	A.	A.	A.	W.
λ					
4250.962			+24.0		+19.8
54.505		+17.8	24.8		19.8
57.815	+19.7				
58.370		12.1	28.7	+43.0	
60.640					24.8
71.325	8.1				
71.934		13.0			
78.390	10.1	18.0			
88.083	16.1	15.0	29.7	43.1	18.9
94.273	17.2				
4300.211		23.1			
02.077					19.5
03.443		19.1	27.0	46.2	
13.034		17.6	29.3		19.0
14.357		15.0			
21.000	12.8	18.1	30.5	48.2	
25.195	17.3	14.4			
25.939	13.7				
38.084		20.5	31.5		24.3
44.481		16.7		45.7	
52.012	20.6		28.2	50.6	20.6
69.651	16.2	14.1		38.0	
83.720	16.0	11.9	27.3	40.7	17.0
87.007		17.1	30.0	45.6	
91.152			26.0	43.5	
99.907	18.2	20.3		42.0	
4400.617	8.3	16.0	24.1		
04.927	16.3	13.2	28.6	43.2	15.1
07.850	11.1		31.8		
11.240	14.7	20.4	30.2	41.7	
16.985		19.5		47.0	
41.861	21.2		28.0		
43.273	15.9				
44.168			30.7	41.6	
50.654	16.3	20.6	31.7	46.5	
64.631	14.8	19.5	26.7	47.2	20.2
68.824	13.9			47.2	
81.364	12.5	16.9	28.2	46.2	17.7
4501.445					23.0
08.455					19.3
15.525					21.2

[illegible] Velorum.—Continued.

Date	1903 Nov. 17.[illegible]	1905 Jan. 1[illegible]	1905 Mar. 7.69	1905 Apr. 24.5[illegible]	1906 Jan. [illegible]
4[illegible]					[illegible].4
[illegible]					[illegible]
Number of lines	22	24	21	19	[illegible]
Mean	−15.16	−17.1[illegible]	−24.43	−44.59	−2[illegible]
Scale Corr.	.06	— .1[illegible]	— .03	— .[illegible]	— .[illegible]
Systematic Corr.	.22	— .22	— .22	— .22	— .22
V_r	−14.94	−16.74	−24.19	−44.3[illegible]	−19.[illegible]
Reduction to ☉	−14.43	— 8.5[illegible]	— 2.91	—12.30	—11.[illegible]
Observed V	−29.27	−25.26	−25.27	−32.0[illegible]	−30.94

Mean V = −2[illegible] km.

Mean J. D. 241[illegible]

Epoch 1905.[illegible]

The character of this spectrum is such that measurements can not be made with the greatest accuracy. Dr. [illegible] considers, however, that the range of some 7 kilometers in his measurements may indicate changes in the star's velocity.

o Velorum R. A. $8^h\ 37^m.3$ Dec. — 52° 34′

Magn. 3.7 Type B3A

Date	1904 Feb. 4.66	1904 Nov. 15.79	1905 Jan. 31.63	1905 Apr. 13.57
Julian day	6515.66	6800.79	6877.63	6949.57
Plate number	165 II	473 III	572 II	691 II
Photographed by	W.	P.	W.	P.
Measured by	W.	A.	P.	P.
λ				
4267.280			+ 0.9	+18.9
4340.634	+ 6.8	— 0.2	2.7	13.4
88.100	14.4	+ 2.6	6.5	19.6
4437.718		+ 5.0	2.0	
71.693	5.4	— 8.9	3.9	23.0
81.375	5.5	— 0.5 wt. 3	1.8	16.9
Number of lines	(4)	(5)	(6)	(5)
Mean	+ 8.02	— 0.43	+ 2.97	+18.36
Scale Corr.	+ .04	.00	.0	.0
Systematic Corr.	— .22	— .22	— .22	— .22
v_s	+ 7.84	— 0.65	+ 2.75	+18.14
Reduction to ⊙	+ 5.93	+11.54	+ 6.59	— 7.64
Observed *V*	+13.77	+10.89	+ 9.34	+10.50

Velocity variable.

a Pyxidis R. A. $8^h\ 39^m6$ Dec. — 32° 49′

Magn. 3.7 Type B2A

Date	1903 Dec. 29.83		1904 Mar. 22.58	1904 Nov. 14.82	1905 Apr. 23.55		1905 Dec. 30.82
Julian day	6478.83		6562.58	6799.82	6959.55		7210.82
Plate number	103 II		255 I	471 IV	709 II		863 IV
Photographed by	P.		P.	P.	P.		W.
Measured by	A.		P.	A.	A.		A.
λ							
4253.821					+36.4	wt. 1	+ 6.2
67.280	— 7.0	wt. ½	+26.8		33.9	1	0.0
4303.946					31.0	½	
17.302	+ 5.6	1			26.4	½	+ 2.3
19.774	+ 1.2	½			34.3	½	+ 1.8
40.634	—21.6	¼	29.1		30.3	½	+ 5.7
45.712	+ 9.6	½			41.9	½	+ 5.2
47.527				λ4450 central. System II	34.8	1	— 1.4
49.576	+11.4	1			35.8	1	+ 2.9
51.426					31.5	1	+ 2.0
67.023	—14.4	½			29.6	1	— 2.6
88.100	— 0.6	1	25.8		34.7	1	+ 3.6
96.022	+ 6.9	½			33.2	1	+ 6.3
4411.255	— 4.1	1					
15.044	— 4.5	½			34.3	1	— 2.0
17.129	— 2.6	1			42.0	1	+ 3.2
37.718	— 3.3	½	46.4 wt. ½		32.3	1	+ 0.6
47.188					32.1	1	
48.322					34.8	½	
65.589					37.2	1	
66.503					29.3	1	
69.832	—13.0	¼					+ 7.3
71.693	+ 6.0	1	30.5		30.2	1	+ 1.2
77.695					42.4	½	
81.375	+ 1.7	1	30.9		35.5	1	+ 9.8
Number of lines	(16)		(6)	(15)	(23)		(18)
Mean	+ .27		+30.24	— 2.17	+34.02		+ 2.89
Scale Corr.	— .01		+ .02	.00	— .08		— .01
Systematic Corr.	— .22		— .22	.00	— .22		— .22
v_s	+ .04		+30.04	— 2.17	+33.72		+ 2.66
Reduction to ☉	+14.61		—11.58	+19.92	—18.07		+14.26
Observed V	+14.65		+18.46	+17.75 wt. ½	+15.65		+16.92

Mean V = +16.57 km. Mean J. D. 2416802.60

Epoch 1904.88

d Velorum R. A. $8^h\ 40^m 8$ Dec. — 42° 17′

Magn. 4.1 Type G5K

Date	1904 Jan. 18.67	1904 Mar. 21.62	1905 Feb. 15.61	1905 Apr. 16.58
Julian day	6498.67	6561.62	6892.61	6952.58
Plate number	136 II	252 I	598 II	698 II
Photographed by	P	P.	W.	P.
Measured by	W	P.	P.	P.
λ				
4238.980		+6.7		
43.981				+12.4
46.968		8.3	— 4.6	11.2
50.287		3.3	— 2.2	
50.962	— 7.0	3.0	— 2.3	12.7
54.505	12.5	2.1	— 2.2	12.7
60.640				14.0
68.866			— 3.6	8.3
74.935		4.9		
78.390		1.9		
82.565		5.6		13.9
83.169				8.1
84.382		0.9		
87.605				10.5
94.273		5.1		
4300.732			+ 0.8	
13.034		1.8		
13.771	11.8			13.2
16.962			— 0.9	13.9
18.867	10.0	6.2	— 1.7	10.7
21.000		0.7		
25.195	10.5	4.2	— 5.4	10.0
25.978	13.0	5.9	+ 0.1	14.2
28.101			— 2.8	12.9
30.866			+ 2.5	17.3
31.795		9.3		12.4
37.216		4.9	— 5.9	11.4
38.084		0.0		
40.634		10.1	— 0.4	11.8
41.530		8.7		
43.402			— 2.5	
52.949	7.3	7.9		
59.784	11.4		— 0.6	12.1
71.363		5.7		
75.119			— 6.0	9.2
76.107		+ 5.9	0.0	11.2
79.396	10.1	— 0.1	— 5.8	
83.720		+ 4.5	— 2.1	12.5
87.007		9.5		
90.118			— 4.8	13.2
95.270	9.4	6.3		

δ *Velorum*—Continued

Date	1904 Jan. 18.67	1904 Mar. 21.62	1905 Feb. 15.61	1905 Apr. 26.56
4398.307		5.8	— 3.5	
4404.927	10.9	4.1	— 1.6	
06.810	12.8	8.4	0.0	12.3
07.880	13.2	5.7		
15.322		3.6		
17.837			— 2.2	
25.608				13.9
27.464	10.4			
28.711			— 3.8	10.8
30.785			— 1.2	9.6
35.817		6.3	— 1.3	10.2
41.861			— 6.2	10.4
42.510	7.3	3.2	— 4.7	11.8
43.376			— 7.5	10.4
47.915			— 3.0	11.1
51.752				9.0
66.789		4.9	— 4.4	11.5
68.673		5.4	— 1.4	9.2
76.214		8.9	— 4.6	12.0
82.376		7.5		
Number of lines	(17)	(38)	(35)	(37)
Mean	—10.51	— 5.19	— 2.48	—11.65
Scale Corr.	— .04	— .01	.00	— .02
Systematic Corr.	— .22	— .22	— .22	— .22
V_s	—10.77	— 4.98	— 2.70	—11.45
Reduction to ☉	— 9.45	— 7.37	— 1.86	—12.93
Observed V	— 1.32	— 2.59	— 0.85	— 1.48

Mean V = —1.56 km.

Mean J. D. 2416726.37
Epoch 1904.67

a *Velorum* R. A. $8^h\ 42^m6$ Dec. — 45° 40′

Magn. 4.1 Type A

Date	1904 Mar. 23.59	1904 Dec. 27.84	1905 Feb. 8.64	1905 Apr. 17.60
Julian day	6563.59	6842.84	6885.64	6953.60
Plate number	259 I	514 III	586 II	702 II
Photographed by	P.	W.	W.	W.
Measured by	W.	W.	W.	W.
λ				
4320.99		+14.0		
40.61	+40.0	7.5 wt. 2	+21.8 wt. 2	+34.0
51.96		9.5	20.4	31.7
95.17			19.2	
4481.39	33.5	10.6 wt. 2	20.0 wt. 2	34.9
4501.45		9.1	16.1	28.7
08.45		7.9	21.2	37.3
20.38			23.6	
22.78		9.8	24.5	39.2
34.19		16.2	22.1	38.8
49.72		7.8	23.0	33.0
Number of lines	(2)	(9)	(10)	(8)
Mean	+36.8	+10.0	+21.1	+34.7
Scale Corr.	0.0	0.0	0.0	0.0
Systematic Corr.	— .2	— .2	— .2	— .2
v_s	+36.6	+ 9.8	+20.9	+34.5
Reduction to ☉	— 6.6	+13.0	+ 4.5	—11.5
Observed V	+30.0 wt. ½	+22.8	+25.4	+23.0

Mean V = +24.6 km. Mean J. D. 2416846.82

Epoch 1905.00

ι Carinae — R. A. $8^h\ 52^m.8$ Dec. — 60° 16′

Magn. 4.0 — Type B8A

Date	1904 May 16.66		1905 Jan. 3.83		1905 Feb. 21.60		1905 Apr. 28.60		1906 Feb. 1.75	
Julian day	[illegible]		[illegible]		6896.60		6964.60		7243.75	
Plate number	240 I		321 III		605 II		720 II		677 II	
Photographed by	W.		W.		W.		W.		W.	
Measured by	W.	A.	W.	A.	W.	A.	W.	A.	W.	A.
λ										
[illegible]				−16.5		−14.6		−30.9		−30.7
[illegible]		−24.3		[illegible]		24.2		27.8		15.6
[illegible]		[illegible]		[illegible]		[illegible]		[illegible]		31.3
[illegible]		[illegible]		[illegible]		[illegible]		40.3		33.9
[illegible]		[illegible]		[illegible]		30.7		[illegible]		6.0
[illegible]		[illegible]		[illegible]		[illegible]		[illegible]		[illegible]
[illegible]		[illegible]		[illegible]		[illegible]		[illegible]		[illegible]
4340.634	−21	[illegible]	[illegible]	[illegible]	−10	[illegible]	−32	[illegible]	−32	[illegible]
[illegible]		[illegible]		[illegible]		[illegible]		[illegible]		[illegible]
[illegible]		[illegible]		[illegible]		[illegible]				[illegible]
[illegible]		[illegible]				[illegible]		[illegible]		[illegible]
4471.688	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
[illegible]		[illegible]		[illegible]		[illegible]		[illegible]		
81.375	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Number of lines	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Mean	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Scale corr.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Systematic corr.	[illegible]		[illegible]		[illegible]		[illegible]		[illegible]	
Reduction to ⊙	[illegible]		[illegible]		[illegible]		[illegible]		[illegible]	
Observed V	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Mean V = [illegible] (A.) — Mean J. D. 2416[illegible]

[illegible] (W.) — Epoch [illegible]

In Mr. Albrecht's measures the radial velocity for this star is based on the four lines λ 4267.259, 4340.634, 4471.688, and 4481.375. The plates were first reduced by using only these four lines. Then the wave-lengths of the other spectrum lines were determined from the measures on each plate. The plates were re-reduced, using all the available lines. Since the wave-lengths of the newly determined lines depend upon the four lines that were used in the first reduction, the mean for all the plates remains unchanged by the second reduction. The advantage gained in the second reduction is a considerably smaller range in the radial velocities of the star as determined from the individual plates.—S. A.

c Velorum R. A. $9^h\ 0^m 7$ Dec. — 46° 42′

Magn. 3.7 Type K

Date	1904 Jan. 5.72	1904 Mar. 12.67	1905 Feb. 21.72	1905 Apr. 26.57
Julian day	6485.72	6552.67	6898.72	6962.57
Plate number	114 II	238 I	606 III	714 II
Photographed by	W.	P.	W.	W.
Measured by	P.	P.	P.	P.
λ				
4222.382	+ 9.2			
38.980		+30.4		
41.287			+22.2	+34.4
46.968	13.4	26.9	21.0	35.7
50.287	12.6	27.5	18.5	36.7
50.962		26.9	20.8	36.9
54.505		24.5		
65.374	16.1		23.0	40.4
68.866	13.7		22.7	35.2
74.935		25.3		
76.836				38.2
78.390		27.9		
83.169	14.7		21.2	
86.627			23.7	36.0
87.605	13.4		24.4	35.7
94.273		27.6		
4313.034		26.1		
13.771		23.6	22.0	31.9
18.867	16.4	29.6	24.1	37.5
25.195			24.8	36.7
28.101	11.8	28.1	21.5	34.7
31.795	9.8	26.0	20.2	35.8
37.216	9.7	26.7	21.0	35.4
38.854			25.8	
40.634		26.1	22.9	31.9
43.402			22.0	36.2
47.464	10.7			
49.150			25.0	32.9
52.972		29.5		
55.294			22.0	
59.784	9.6		21.7	35.5
69.924		27.3		
71.363		28.6		
73.727	16.5			
75.119	12.1	26.8	23.4	37.0
76.107	11.3	25.3	23.6	35.9
79.396	6.6	24.5	20.1	33.1
88.629	12.8		23.1	
89.413	10.9		22.3	
90.118	8.4	28.0	23.5	38.4
91.152		25.6		

α Volantis R. A. $9^h\ 0^m9$ Dec. — 66° 0′

Magn. 4.2 Type A5F

Date	1903 Dec. 14.77	1904 Feb. 11.75	1904 Dec. 24.76	1905 Jan. 15.72	1905 Mar. 22.62
Julian day	6463.77	6522.75	6839.76	6861.72	6927.62
Plate number	82 IV	181 II	510 III	539 II	651 II
Photographed by	P.	P.	P.	W.	W.
Measured by	W.	W.	W.	W.	W.
λ					
4254.51	— 2.2	+52.5	+ 3.8		+ 3.2
60.65	— 3.2	43.8	— 0.7	— 5.7	— 1.9
71.934		51.3			
4308.06	— 0.7	49.9	— 0.3	+ 5.8	+ 5.2
25.939			+ 0.3	+ 1.1	+ 6.7
40.61	+ 4.6			— 6.4	— 1.8
51.96	+ 1.1		+ 4.0	— 1.8	+ 3.6
83.71	— 4.2	42.0	+ 1.5	+ 4.2	— 2.3
95.242	— 2.2		— 3.7	— 4.5	— 5.3
4404.927	+ 3.1	60.5	— 0.4	— 1.2	+ 2.7
81.39	— 2.6	52.4	— 1.7	+ 1.7	+ 6.4
4501.45			— 1.3		— 1.3
08.45			— 0.9	+ 2.2	
15.52					+ 8.8
20.38			— 6.2		+ 4.4
22.78			+ 4.9	0.0	+ 5.8
34.19			+ 1.4	— 0.4	
49.72			— 5.0	— 1.4	
Number of lines	(9)	(7)	(15)	(13)	(14)
Mean	— 0.9	+50.3	— 0.3	— 0.5	+ 2.4
Scale Corr.	0.0	+ 0.2	0.0	0.0	0.0
Systematic Corr.	— .2	— .2	— .2	— .2	— .2
v_s	— 1.1	+50.3	— 0.5	— 0.7	+ 2.2
Reduction to ⊙	+ 8.2	+ 8.1	+ 9.0	+ 9.4	+ 3.4
Observed V	+ 7.1	+58.4	+ 8.5	+ 8.7	+ 5.6

Mean V (excluding plate 181 II) = +7.5 km. Mean J. D. 2416773.22,

Velocity variable. Epoch 1904.80

This is a spectroscopic binary system in which both spectra are bright enough to record on the plate. Of the plates here referred to only the second shows the lines in the two spectra to be completely separated. The breadth of the lines on the other plates varies according to the star's phase. It is believed that the mean of all the observations, excepting the second, gives a fair value of the velocity of the system.

The velocity of the fainter component, from the measurement of five lines on plate 181 II is —51± km. From this the ratio of the masses would appear to be about as 7 to 6, the brighter being the heavier.

Further observations of this star kindly secured by Dr. Curtis are:

1907 Jan.	4.83	lines	broad.
	7.83	"	sharper.
	10.82	"	broad. λ4481 double?
	11.80	"	v. broad. λ4481 seems double.
March	19.63	"	sharp.
May	13.49	"	well separated (105 km.).
	14.48	"	well separated (92 km.).

The fact that the lines are completely separated on only a few of the plates would appear to indicate that the eccentricity of the orbit is large.

λ Velorum R. A. $9^h\ 4^m3$ Dec. — 43° 2′

Magn. 2.2 Type K5M

Date	1903 Nov. 21.84	1903 Nov. 22.83	1904 Dec. 10.82		1905 Mar. 15.62	1906 Jan. 27.65
Julian day	6440.84	6441.83	6825.82		6920.62	7238.65
Plate number	56 II	58 II	491 IV		638 III	873 II
Photographed by	P.	W.	P.		W.	W.
Measured by	R. H. C.	P.	W.	P.	P.	W.
λ						
4222.382		+ 0.5				
39.525		0.0			+18.7	
41.287					20.3	
46.968		+ 1.2			21.1	
50.287		+ 0.6			21.5	
50.962		+ 2.1			23.9	
65.374		— 1.0				+ 6.8
68.866		+ 3.7			24.1	
86.627		+ 2.2			25.9	
87.605		0.0			22.5	
4313.034		+ 2.6				
13.771	+ 6.0					
18.867		+ 4.5			22.4	13.4
28.101	+ 1.6				25.7	8.5
30.189		+ 4.6			25.3	
31.795	+ 4.0					6.7
37.216	+ 2.2	+ 0.2	λ4450 central. System II	λ4450 central. System I	22.6	
41.530	— 1.1					
47.464		— 1.1			23.5	
49.150	+ 1.7				24.6	9.8
55.294	+ 0.1	+ 1.2			22.0	
59.784		+ 2.6			24.5	13.2
69.924						14.1
75.119	+ 4.0				23.4	
76.107	+ 1.9	— 0.4			23.4	13.1
79.396	+ 3.4	— 1.1			22.2	7.5
88.100		+ 2.9				
88.629	+ 1.3	+ 3.0			21.0	
89.413	+ 1.7	+ 2.1			23.7	
90.143		+ 1.7			25.2	
91.152						10.6
95.298						7.4
4406.810	— 1.4	+ 0.6			24.4	7.8
07.850						8.2
11.240	0.0					
17.857	+ 0.2	+ 5.2			24.8	
18.542	— 1.4					
27.444						9.6
28.711		— 0.6				6.4
33.414	+ 3.0					
35.817		+ 4.1				

λ *Velorum*—(Continued)

Date	1903 Nov. 21.84	1903 Nov. 22.83	1904 Dec. 10.82		1905 Mar. 15.62	1906 Jan. 27.65
			λ4450 central. System II	λ4450 central. System I		
4438.006					21.2	
41.861		+ 2.5			20.2	8.1
42.510	+ 2.0	+ 2.2			23.3	11.0
47.915	+ 1.7	— 0.2			21.7	8.6
51.732		0.0				
59.324						10.2
66.789		+ 3.8			21.1	
68.745		— 0.7			19.7	
76.214					19.6	
89.911		+ 4.5			27.2	
4501.445		— 1.1				
12.906		+ 2.7				
Number of lines	(19)	(34)	(25)	(34)	(32)	(19)
Mean	+ 1.63	+ 1.54	+ 0.95	— 1.05	+22.83	+ 9.52
Scale Corr.	.00	.00	.00	.00	+ .03	— .03
Systematic Corr.	— .22	— .22	— .00		— .22	— .22
v_s	+ 1.41	+ 1.32	— .05		+22.64	+ 9.27
Reduction to ☉	+16.74	+16.82	+16.79		— 4.13	+ 9.34
Observed *V*	+18.15	+18.14	+16.74 wt. ½		+18.51	+18.61

Mean *V* = +18.17 km.

Mean J. D. 2416767.97
Epoch 1904.78

G *Carinae* R. A. $9^h\ 4^m9$ Dec. — 72° 12′

Magn. 4.5 Type F5G

Date	1903 Dec. 19.79	1905 Feb. 8.76	1905 Mar. 8.68	1905 Apr. 5.64
Julian day	6468.79	6885.76	6913.68	6941.64
Plate number	89 II	587 III	622 II	683 II
Photographed by	P.	W.	W.	W.
Measured by	A. M. H.	W.	W.	W.
λ				
4246.99	+32		+18	
58.33	30			
60.65	7	+ 8	6	+ 6
4308.06	19			10
13.034		2		
20.99	16	7	17	15
40.61	27	19	17	22
44.45	25			
83.71		5	5	10
95.21	26			
4404.91	16	9	11	16
50.66		15		
64.64	19	20	27	
4501.45	24	14		21
08.45	24	13	20	10
15.52	11		13	
20.38			14	12
22.78	26	13	16	21
34.19	14			
49.72	18	13	8	10
72.15	6			
Number of lines	(17)	(12)	(12)	(11)
Mean	+20.0	+11.5	+14.3	+13.9
Scale Corr.	+ .1	.0	.0	.0
Systematic Corr.	— .2	— .2	— .2	— .2
v_s	+19.9	+11.3	+14.1	+13.7
Reduction to ☉	+ 6.4	+ 8.5	+ 6.8	+ 3.6
Observed V	+26.3	+19.8	+20.9	+17.3

Mean V = +21.1 km. Mean J. D. 2416802.47

Epoch 1904.88

The lines in this spectrum are very diffuse, and the observations are accordingly subject to great uncertainty. The range shown by them is perhaps no greater than might be expected to result from this fact.

a *Carinae* R. A. 9^h $8^m.4$ Dec. — 58° 33′

Magn. 3.6 Type B3A

Date	1904 Feb. 29.67		1905 Jan. 30.68		1905 Feb. 9.64		1905 Feb. 22.62		1905 Mar. 7.56
Julian day	6540.67		6876.68		6886.64		6899.62		6912.56
Plate number	199 I		570 II		588 II		607 III		617 II
Photographed by	W.		W.		W.		W.		W.
Measured by	W.	P.	W.	P.	W.	P.	W.	P.	P.
λ									
4267.280	— 0.4	— 0.3	+23.7	+24.2	+ 1.2	+ 2.0	— 0.4	— 1.1	— 4.1
4340.634	+ 0.2	+ 0.7	22.2	22.6	+ 2.1	+ 5.0	+ 0.5	— 1.6	— 8.8
88.100	+ 7.1	+ 8.4	26.0	29.8	+ 2.7	+ 2.3	— 3.6	+ 4.3	— 1.9
4437.718		— 3.9	20.6	26.1		+ 5.5		— 1.6	— 0.4
71.693	— 6.1	— 1.9	22.0		— 3.2	— 0.9	— 4.2	— 6.7	— 7.6
81.375	+ 2.7	+ 4.2	22.4	22.4	+ 2.1	+ 2.9	— 1.1	— 0.5	— 6.0
Number of lines	(5)	(6)	(6)	(5)	(5)	(6)	(5)	(6)	(6)
Mean	+ 0.7	+ 1.2	+22.8	+25.0	+ 1.0	+ 2.8	— 1.8	— 1.2	— 4.8
Scale Corr.	.00		— .02		.00		.00		.00
Systematic Corr.	— .22		— .22		— .22		— .22		— .22
v_s	+ .73		+23.66		+ 1.68		— 1.72		— 5.0
Reduction to ⊙	+ 4.36		+ 9.15		+ 7.76		+ 5.61		+ 3.22
Observed V	+ 5.09		+32.81		+ 9.44		+ 3.89		— 1.8

Velocity variable. Velocity of system (Curtis) = +23.3 km.

For elements see addendum.

g *Carinae*—(Continued)

Date	1903 Dec. 20.77	1905 Jan. 19.81	1905 Mar. 10.69	1906 Feb. 2.66
4447.915	17.0	13.0	5.7	
51.752		18.0		
59.324				15.1
66.789	12.8	15.7	6.1	
68.745	14.0	17.3	12.3	
76.214	13.0	17.1	12.4	
4501.445	17.3			
05.003	13.4			
12.906	16.4			
Number of lines	(28)	(30)	(31)	(20)
Mean	−16.24	−16.51	− 7.70	−14.62
Scale Corr.	+ .01	+ .06	.00	+ .05
Systematic Corr.	− .22	− .22	− .22	− .22
v_s	−16.45	−16.67	− 7.92	−14.79
Reduction to ☉	+12.34	+10.68	+ 2.30	+ 9.13
Observed V	− 4.11	− 5.99	− 5.62	− 5.66

Mean V = −5.34 km.

Mean J. D. 2416873.98
Epoch 1905.07

ι Carinae R. A. 9^h 14^m4 Dec. — 58° 51′

Magn. 2.2 Type F

Date	1903 Dec. 5.83	1904 Feb. 3.62	1904 Nov. 17.85	1905 Mar. 10.60	1905 Nov. 23.85	1905 Nov. 24.82
Julian day	6454.83	6514.62	6802.85	6915.60	7173.85	7174.82
Plate Number	69 III	163 III	475 III	624 II	835 IV	838 IV
Photographed by	P.	W.	W.	W.	W.	W.
Measured by	R. H. C.	P.	A.	P.	A.	P.
λ						
4187.204		+ 4.9				
99.267		5.0				
4202.198		5.5				
22.382		2.3				
26.904		3.7		+ 4.7		
33.328		7.5		6.4		
33.772		9.5				
38.980					+ 1.2	+ 3.0
46.968	+ 2.3	6.3		10.4	+ 4.0	4.6
50.287		3.2		8.2	+ 3.6	2.9
50.962	2.2	3.6		8.1	— 0.7	4.8
52.785	2.7					
54.505	1.9	6.2		9.9	+ 3.8	5.4
58.370					8.2	
60.640	2.4			9.7		6.1
62.086	0.5					
71.325			λ4450 central. System II		4.7	
71.934	4.3				3.3	
74.935	+ 4.0				4.6	4.2
78.390	— 2.5				1.2	1.3
82.565		3.5		8.1	3.8	3.3
83.169				9.6		5.1
84.382	— 0.3					
88.083	+ 2.8				2.5	
90.377	5.1					
94.273					3.4	0.5
96.735	4.6					
99.410	3.4					
4300.211	4.1	6.8		10.5	3.6	2.4
.02.085	3.3					
02.692	6.2					
03.337	5.7			10.9	4.8	1.5
13.034	4.2	6.1		9.9	4.8	0.2
14.357					2.4	
16.962				7.7		
18.867		4.0				
21.000					2.3	3.5
25.195	2.0	4.4		7.2	1.9	3.7
25.939	3.0	4.1		8.6	1.9	4.9
30.866	5.0	8.7		11.2		
37.216						2.8

ι Carinae—(Continued)

Date	1903 Dec. 5.83	1904 Feb. 3.62	1904 Nov. 17.85	1905 Mar. 10.60	1905 Mar. 23.85	1905 Nov. 24.82
4338.084	2.9	3.6		9.7	3.9	
40.634				9.0	+ 4.5	
41.530	+ 4.7					
52.949						4.2
67.749				12.6		
75.119	— 0.7				— 1.1	0.2
76.107		8.1		7.5		3.6
83.720	+ 5.7	5.2		11.7	+ 3.0	2.6
85.548	4.6					
87.007	5.0					5.5
91.152	5.0					
94.225	4.4					
95.242	1.0				4.1	1.6
96.008	3.5					
99.907	6.6	2.5		13.1	4.3	5.6
4400.555	4.9					
04.927	2.4	3.5		8.1	1.8	5.6
07.850	4.3					
15.722	3.2		λ4450 central. System II			
16.985	3.6				1.6	2.0
17.857	4.8	7.2		11.3	4.7	5.9
18.542						6.5
27.444					8.0	
41.861				12.5		7.5
42.510				13.8		
43.976	+ 2.9	5.7		9.2	1.4	1.8
47.915				8.0		
50.654					0.5	4.8
59.324					0.2	
64.631					0.0	
66.727				7.3		
68.623		7.1		10.9	1.0	5.0
71.017				8.4		
76.211						0.0
81.364				12.1	+ 4.7	4.0
82.376						2.4
4508.455		5.9				
Number of lines	(40)	(27)	(36)	(32)	(36)	(36)
Mean	+ 3.39	+ 5.34	+ 2.60	+ 9.57	+ 3.00	+ 3.53
Scale Corr.	.00	.00	.00	.00	.00	— .01
Systematic Corr.	— .22	— .22	00	— .22	— .22	— .22
v_s	+ 3.17	+ 5.12	+ 2.60	+ 9.35	+ 2.78	+ 3.30
Reduction to ⊙	+11.05	+ 9.17	+ 9.33	+ 3.01	+10.01	+10.16
Observed V	+14.22	+14.29	+11.93 wt. ½	+12.36	+12.79	+13.46

Mean V = +13.29 km.

Mean J. D. 2416842.75
Epoch 1904.99

κ Velorum R. A. $9^h\ 19^m0$ Dec. — 54° 35′

Magn. 2.6 Type B3A

Date	1904 Mar. 6.74	1905 Jan. 14.70	1905 Feb. 20.65	1905 Mar. 7.60
Julian day	6546.74	6860.70	6897.65	6912.60
Plate number	216 I	535 II	602 II	618 III
Photographed by	W.	W.	W.	W.
Measured by	W.	P.	P.	P.
λ				
4267.280		0	+62	+51
4340.634	+65	— 2	60	49
88.100	60	+ 2	58	48
4437.718			54	51
71.693	62	— 2	56	48
81.375	66	+ 1	61	53
Number of lines	(4)	(5)	(6)	(6)
Mean	+63.2	— 0.2	+58.5	+50.0
Scale Corr.	+ 0.3	0.0	0.0	0.0
Systematic Corr.	— 0.2	— 0.2	— 0.2	— 0.2
v_s	+63.3	— 0.4	+58.3	+49.8
Reduction to ⊙	+ 2.69	+12.04	+ 5.98	+ 2.72
Observed V	+66.0	+11.6	+64.3	+52.5

Velocity variable. Velocity of system = +21.9 km.

For elements of the orbit of this star see addendum.

[illegible] R. A. $9^h\ 28^m2$ Dec. — 56° 36′

Magn. [illegible] Type K5M

Date	[illegible] Dec. [illegible]	1904 Mar. 4.73	1904 Dec. 17.81	1905 Mar. 18.65	1906 Feb. 2.79
[illegible]	[illegible]	6344.73	6832.81	6923.65	7244.79
Plate number	[illegible] III	212 II	498 III	647 II	879 III
Photographed by	W.	W.	P.	P.	W.
Measured by	[illegible]	P.	P.	P.	W.
λ					
[illegible]				—14.5	
[illegible]			—26.3	[illegible]	—[illegible]
[illegible]	[illegible]		22.7	15.3	
[illegible]				[illegible]	
[illegible]	[illegible]			[illegible]	
[illegible]	[illegible]		31.2	[illegible]	[illegible]
[illegible]	[illegible]		26.9	[illegible]	
[illegible]	[illegible]				
[illegible]				[illegible]	
[illegible]	[illegible]				
[illegible]	[illegible]				
[illegible]	[illegible]				
[illegible]	[illegible]				
[illegible]				[illegible]	
[illegible]				[illegible]	
[illegible]	[illegible]		23.4	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]
[illegible]				[illegible]	
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[illegible]					[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]					[illegible]

l Carinae R. A. 9h 42m5 Dec. — 62° 3′

Magn. 3.6 —5.0 Type G. Cepheid variable.

Date	1904 Apr. 18.61	1904 Apr. 30.60	1904 May 8.60	
Julian day	6589.61	6601.60	6609.60	
Plate number	299 II	311 II	312 II	
Photographed by	W.	W.	P.	
Measured by	A.	A.	P.	A.
λ				
4250.287			—10.4	— 8.0
50.962			8.9	9.7
92.324				9.0
96.087	+11.0	+21.5		8.8
4306.921				9.6
13.034	10.2		12.9	10.4
25.195		25.7	12.9	8.8
28.101	10.4	27.2	6.7	4.9
34.101	12.6	21.1		12.1
52.012	8.5			13.3
52.949	10.3	21.2	10.3	7.6
71.328	15.6	21.3	7.3	10.9
76.107	8.0	22.8	7.3	11.9
83.720			15.3	11.8
87.007	13.2	19.0		12.0
91.152	7.7	12.4	13.0	10.3
4400.675	8.5			7.8
01.611	12.2	25.3		7.2
04.927	9.6	30.3	8.8	7.7
07.850		28.3	14.7	9.8
27.444	13.8	32.4		7.6
41.861	10.2		7.8	6.8
42.510			6.9	6.4
43.273				10.9
47.915	8.6	22.5	5.6	8.3
50.745	11.2	24.1	10.8	10.5
59.324	10.6	21.3		7.4
64.749	16.0	21.5		8.7
66.789	11.4	23.8	8.6	8.4
76.211	11.1	21.5	8.3	8.3
Number of lines	(21)	(19)	(18)	(30)
Mean	+10.99	+23.33	— 9.81	— 9.16
Scale Corr.	.00	+ .01	— .01	— .01
Systematic Corr.	— .22	— .22	— .22	
v_s	+10.77	+23.12	— 9.72	
Reduction to ⊙	— 2.79	— 5.10	— 6.49	
Observed V	+ 7.98	+18.02	—16.21	

Velocity variable.

υ Carinae R. A. $9^h 44^m 6$ Dec. — 64° 37′

Magn. 3.2 Type F

Date	1903 Dec. 7.84	1904 Feb. 25.76	1904 Dec. 8.83	1905 Mar. 12.60		1905 Dec. 15.84
Julian day	6456.84	6536.76	6823.83	6917.60		7195.84
Plate number	72 III	193 II	484 IV	630 II		856 IV
Photographed by	W.	P.	P.	P.		W.
Measured by	P.	P.	W.	P.	W.	W.
λ						
4199.267	+ 2.1					
4222.382	1.1					
46.968	5.7	+ 1.1		+ 7.8		
50.287	2.2	3.0		4.7	+ 2.3	+ 5.5
50.945	1.3			8.7	6.3	4.4
54.505	6.9			10.3	7.4	3.8
60.640				9.7	7.4	5.2
71.325					4.6	3.3
71.934					3.6	5.6
82.565	0.8	6.0		7.6	8.6	5.6
88.038					6.3	7.3
90.410					7.7	4.4
4300.211	4.1			8.8	8.2	6.5
02.085			λ4450 central. System II		7.8	3.7
03.337	2.4	8.8				
13.034	4.0	8.5		9.2	7.3	4.8
16.962	4.9	8.4			2.0	6.2
25.195				4.0	2.3	0.2
25.939	0.5	7.1		9.2	8.4	2.5
30.866	5.5			8.7		
37.216		10.1				
38.084	4.5			11.3	7.9	5.7
40.634					8.6	2.9
75.103		5.1		9.9		
83.720	5.2	6.7		8.7	6.4	4.2
99.935	1.6	8.3		7.1	6.6	5.0
4404.927	4.7	5.5		7.6	4.7	3.1
15.722	2.4			9.3		
17.857	8.4	5.8		9.3	7.9	6.0
18.499					7.5	7.9
41.861				8.4		
43.976	4.9	3.7		5.5	5.7	7.3
44.728				7.8		
68.623	6.5	7.8		8.1	7.5	9.2
76.214				4.9		
81.375				12.0	5.4	8.8
4501.445	2.8	6.8				
08.455	7.0	3.3				
Number of lines	(23)	(17)	(20)	(24)	(25)	(25)
Mean	+ 3.89	+ 6.24	+ 4.50	+ 8.28	+ 6.34	+ 5.15
Scale Corr.	.00	— .01	— 0.01	— .01		— .01
Systematic Corr.	— .22	— .22	.00	— .22		— .22
v_s	+ 3.67	+ 6.01	+ 4.49	+ 7.08		+ 4.92
Reduction to ⊙	+ 9.39	+ 8.18	+ 9.60	+ 5.87		+10.29
Observed *V*	+13.06	+14.19	+14.09 wt. ½	+12.95		+15.21

Mean *V* = +13.88 km. Mean J. D. 2416781.99

Epoch 1904.82

Some of the wave-lengths used in reducing the observations of this star differ slightly from those indicated in the table on page 76.

m *Velorum* R. A. $9^h\ 47^m9$ Dec. — 46° 5′

Magn. 4.6 Type G5K

Date	1905 Jan. 10.74	1905 Jan. 28.69	1905 Mar. 13.70	1905 Apr. 3.67		1905 Dec. 6.81
Julian day	6856.74	6874.69	6918.70	6939.67		7186.81
Plate number	534 II	566 II	633 II	677 II		846 III
Photographed by	W.	W.	P.	W.		W.
Measured by	W.	P.	P.	W.	A.	W.
λ						
4246.968		—16.2	+ 9.2			
50.287		11.2	8.0	+20.1		—17.1
50.962		11.9	7.1	20.6		15.7
54.505			7.8	15.1	+16.2	
4318.867		17.8	6.7	17.0	17.6	24.5
23.386			8.2			
25.978				16.3		
28.101	—25.4	13.0	6.7	21.3	20.2	22.0
31.795	20.2	10.9				18.7
34.101					15.3	
37.216			10.7	19.4		19.8
40.634				17.0		17.7
44.625					12.9	
46.725		14.1				
52.949						19.1
59.784	18.7	14.5	7.5	16.0	17.1	22.4
69.924	21.9					
71.363					14.5	
75.119	14.2					
76.107	18.3	13.1	8.2		13.8	20.6
79.396	24.5		7.9	18.4	15.1	25.2
83.720				20.4		19.7
95.270					16.7	
99.907				14.6		25.1
4400.675					21.0	
01.611					13.9	
04.927	15.5			21.0		19.2
06.810		14.8		17.6		22.0
07.850					19.1	
15.312					20.3	
17.857		13.8				
27.444	19.2					
28.711		11.4				
30.785		15.4				
41.861		16.1	5.6			
42.510		13.2	9.1		21.1	
43.273					14.8	
47.915		9.1	6.8		11.1	
50.654					20.7	
59.324	17.5				18.1	
66.789	23.8	10.3	9.2			

m *Velorum*—(Continued)

Date	1905 Jan. 10.74	1905 Jan. 28.69	1905 Mar. 13.70	1905 Apr. 3.67		1905 Dec. 6.81
4468.673		12.9	5.7		17.4	
76.214	20.7	11.0	6.3	16.2		
85.846		14.7	5.3			
Number of lines	(12)	(20)	(18)	(15)	(20)	(15)
Mean	—19.99	—13.27	+ 7.55	+18.07	+16.84	—20.59
Scale Corr.	.00	.00	.00	.00	— .02	.00
Systematic Corr.	— .22	— .22	— .22	— .22		— .22
v_s	—20.21	—13.49	+ 7.33	+17.22		—20.81
Reduction to ⊙	+16.01	+12.81	+ 0.53	— 5.71		+17.58
Observed *V*	— 4.20	— 0.68	+ 7.86	+11.51		— 3.23

Velocity variable.

The first plate is underexposed and only suitable for approximate measurement.

φ Velorum R. A. $9^h\ 53^m4$ Dec. — 54° 5′

Magn. 3.7 Type B5A

Date	1904 Apr. 7.61	1905 Jan. 14.77	1905 Feb. 23.74	1905 Mar. 19.65
Julian day	6578.61	6860.77	6900.74	6924.65
Plate number	282 I	536 III	609 III	650 II
Photographed by	P.	W.	W.	P.
Measured by	W.	P.	A.	A.
λ				
4267.280	+18.5	+ 6.2	+ 9.4	+ 7.7
4340.634	8.0	— 4.1	3.9	13.0
88.100	24.5	+12.2	5.9	12.9
4447.188				
71.693	16.6	— 1.5	7.1	13.8
81.375	16.8	+ 0.6	3.8	12.2
Number of lines	(5)	(5)	(5)	(5)
Mean	+16.88	+ 2.68	+ 6.02	+11.92
Scale Corr.	.0	.0	— .01	— .01
Systematic Corr.	— .22	— .22	— .22	— .22
v_s	+16.66	+ 2.46	+ 5.79	+11.69
Reduction to ⊙	— 3.22	+14.33	+ 7.56	+ 1.68
Observed V	+13.44	+16.79	+13.35	+13.37

Mean $V = +14.24$ km. Mean J. D. 2416816.19

Epoch 1904.92

q *Carinae* R. A. $10^h\ 13^m.7$ Dec. — 60° 50′

Magn. 3.4 Type K5M

Date	1904 Feb. 5.71	1904 Mar. 22.67	1904 Apr. 4.65	1904 Dec. 23.78	1906 Feb. 14.67
Julian day	6516.71	6562.67	6575.65	6838.78	7256.67
Plate number	169 II	256 II	272 I	508 III	887 II
Photographed by	W.	P.	P.	P.	W.
Measured by	W.	P.	P.	P.	W.
λ					
4238.980		+ 5.1		— 9.1	
46.968		6.0	+ 5.0	3.7	— 0.6
50.287		2.1	5.6	0.0	+ 1.9
50.962				1.8	— 0.7
65.374				9.2	— 1.3
76.836		5.6			
78.390		5.0	8.0		+ 0.7
82.565					+ 0.7
83.169					— 2.0
87.605		7.4			— 1.3
94.273		4.0			
4318.867		9.9		5.3	+ 0.9
21.00				—10.5	
25.195				+ 2.3	
28.101	— 2.5	5.3	7.0	— 2.6	— 1.4
30.41				— 8.0	
30.87				+ 1.2	
31.795	1.0	3.0	5.8	— 2.4	— 5.0
37.216		2.1	8.2	4.3	
47.464	7.4				— 6.7
49.150					— 3.6
52.990		6.5	6.5		
55.294		2.4	7.6		
59.784	1.8			3.1	— 0.7
69.924	4.5			1.8	— 5.6
71.363		5.4	5.4	4.2	
75.119		3.7			— 4.9
76.107		4.9	7.1	3.9	— 3.0
79.396	8.3	1.2	3.4	4.9	— 4.9
87.007			5.2		
90.143		2.4	7.9	3.8	—5.1
91.152		4.4	6.4	7.0	— 2.7
95.298			4.3		— 4.0
4406.810		3.8		2.3	— 4.7
07.850	8.6	4.2	9.8	4.8	— 3.5
18.542		5.2			
27.444	1.6				— 1.2
28.711	9.6				— 6.0
30.785		7.1	3.2		
33.414				3.2	
41.861		6.5	4.7	9.5	— 1.2

η *Carinae*—(Continued)

Date	1904 Feb. 5.71	1904 Mar. 22.67	1904 Apr. 4.65	1904 Dec. 23.78	1906 Feb. 14.67
4442.510	4.1	7.4	9.0	6.5	+ 1.2
47.915	4.9	2.4	7.5	4.5	— 3.7
59.324	4.3				
66.789	3.3	5.6	7.8	6.1	
68.745	8.3	1.6	4.3	8.1	
69.545	0.4				
76.214	7.2	5.0	8.0	4.9	
82.376	8.1	5.4	7.9		
85.846		7.0	6.2	3.9	
Number of lines	(17)	(31)	(25)	(30)	(28)
Mean	— 5.05	+ 4.76	+ 6.47	— 4.53	— 2.44
Scale Corr.	— .01	.00	.00	.00	+ .01
Systematic Corr.	— .22	— .22	— .22	— .22	— .22
v_s	— 5.28	+ 4.54	+ 6.25	— 4.75	— 2.65
Reduction to ☉	+12.45	+ 4.10	+ 1.08	+13.45	+11.25
Observed V	+ 7.17	+ 8.64	+ 7.33	+ 8.70	+ 8.60

Mean V = +8.09 km.

Mean J. D. 2416750.10
Epoch 1904.73

s Carinae R. A. $10^h\ 24^m2$ Dec. — 58° 14′

Magn. 4.1 Type F

Date	1904 Jan. 31.73	1904 Mar. 30.68	1904 Apr. 23.59	1905 Mar. 11.63
Julian day	6511.73	6570.68	6594.59	6916.63
Plate number	160 II	268 I	309 II	627 II
Photographed by	W.	W.	P.	W.
Measured by	P.	P.	P.	P.
λ				
4202.198	— 1.5			
22.382	0.2			
46.968	0.4		+14.8	+ 5.5
50.287	5.4	+ 7.7	10.6	1.4
50.945	2.4		14.1	4.6
54.505		5.6	10.0	3.8
60.640	3.2			3.5
82.565	4.5	6.5	12.2	2.8
4300.211			15.2	3.7
03.337				5.4
13.034				3.8
16.962			17.6	6.6
18.867			11.6	
25.195	4.9		13.6	3.5
25.939	2.3	6.9	14.8	3.7
38.084			17.1	4.3
40.634				2.1
59.784	1.3			9.4
76.107	.9		12.8	6.2
83.720	7.4	12.9	9.2	4.0
99.907			13.8	5.6
4404.927	6.1	9.2	13.8	4.3
17.857	2.0	5.7	12.7	9.7
25.608	.2			3.4
30.785		10.5	13.2	1.0
35.817				4.9
41.861		12.5		
42.510	5.7	12.2		6.7
43.976	1.4	12.3	10.1	4.1
44.728				5.9
66.727	6.9	9.6	12.1	.2
68.623	3.8	12.1	16.2	4.8
76.214				.4
81.375				4.8
4501.445	1.5		10.8	
08.455	2.2	7.5	18.4	
Number of lines	(21)	(14)	(22)	(30)
Mean	— 3.06	+ 9.37	+13.40	+ 4.34
Scale Corr.	.00	+ .02	.00	.00
Systematic Corr.	— .22	— .22	— .22	— .22
v_s	— 3.28	+ 9.17	+13.18	+ 4.12
Reduction to ⊙	+13.89	+ 1.96	— 4.17	+ 6.77
Observed V	+10.61	+11.13	+ 9.01	+10.89

Mean V = +10.41 km. Mean J. D. 2416648.41

Epoch 1904.46

p *Velorum* R. A. $10^h\ 33^m2$ Dec. $-47°\ 43'$

Magn. 4.1 Type F2G

Date	1903 Dec. 14.84	1904 Feb. 6.85	1904 Dec. 31.80	1905 Jan. 25.74	1905 Jan. 26.70
Julian day	6463.84	6517.85	6846.80	6871.74	6872.70
Plate number	83 III	173 III	516 III	557 III	560 III
Photographed by	P.	W.	P.	P.	W.
Measured by	W.	W.	W.	W.	W.
λ					
4250.287			—1.3	+14.0	
50.945	+16.9	+21.3	+6.4		+21.3
54.505	14.1	24.6	+1.9	6.7	21.4
60.640	19.0			8.7	23.2
71.325			0.0		
71.934	16.7	27.1	+3.9		22.6
74.935	19.3		+5.2		
82.565	16.6	22.6	0.0	15.6	19.6
4300.211	20.1	24.5	+3.1		23.1
03.337	14.7		+4.8		
13.034	17.9		+5.2		
25.939	14.1	21.8	+3.2	5.3	20.4
40.634		15.0			
51.96	22.2	31.7	+4.4	9.5	26.6
75.119			—1.5		
76.107		31.4	+1.5		24.3
83.720	12.5	27.2	+3.0	6.8	23.1
95.242	15.0	22.9	—2.8	3.4	22.2
4404.927	12.8	21.7	+3.5	10.5	24.8
16.985			+3.2		
27.444	22.3		+4.8		25.5
Number of lines	(15)	(12)	(19)	(9)	(13)
Mean	+16.89	+24.32	+ 2.55	+ 8.94	+22.93
Scale Corr.	+ 0.10	+ 0.01	— 0.01	— .01	— 0.06
Systematic Corr.	— .22	— .22	— .22	— 22.	— .22
v_s	+16.77	+24.11	+ 2.32	+ 8.71	+22.65
Reduction to ☉	+18.57	+14.29	+19.09	+16.67	+16.58
Observed V	+35.34	+38.40	+21.41	+25.38	+39.23

Double line spectroscopic binary.

The measurements here given concern the brighter component of this spectroscopic system. On the plate of 1904, December 31, the lines are single, while on the following plate, though apparently single they are hazy. In the latter case the velocity determination is not believed to represent anything very definite on account of the confusion of lines of the two spectra, which differ somewhat in type and considerably in intensity. On three of the plates approximate measurements of the velocity of the fainter component could be made, and are as follows:

Plate Number	Number of Lines	Velocity (reduced to ☉)
83 III	6	— 4 km.
173 III	3	—10
560 III	4	— 6

Assuming the velocity of the system to be +22 km., the ratio of the masses of the two components appears to be about as 1.8:1, the brighter being the heavier.

The second plate gives an unusually large range in the values of the velocity determined from the individual lines. This is probably due to the blending of the two spectra.

γ Chamaeleontis R. A. $10^h\ 34^m3$ Dec. — 78° 6′

Magn. 4.1 Type Ma

Date	1904 Apr. 1.67	1904 Apr. 15.70	1905 Feb. 11.66	1905 Mar. 28.68	1906 Feb. 23.84
Julian day	6572.67	6586.70	6888.66	6933.68	7265.84
Plate number	269 I	291 II	594 II	662 II	894 IV
Photographed by	W.	W.	W.	W.	H.D.C.
Measured by	W.	P.	P.	W.	W.
λ					
4246.968			—34.3		
50.287			28.3		
50.962			35.8		
58.50			33.0		
4318.867		—26.7	28.2		
21.00		35.0			
25.195			32.4		
28.101		23.4	33.6	—27.9	—38.1
31.795	—27.8		35.0	26.9	
37.216		26.9	34.2	33.2	
46.725			35.1		
53.008	27.0	27.5	33.9		38.0
59.784	28.9			29.4	
69.924	29.3	27.6	35.0	34.0	
71.363		29.0	34.7		
75.119			34.4		
76.107	21.2	25.4	35.0	32.2	
79.396	24.3	26.0	34.4	32.7	35.3
90.168		31.5	34.3		
91.152			33.4		
95.298			34.1		
4406.810			34.1	28.8	
07.850			35.5	33.9	37.1
16.985			30.5		
27.444	28.3			32.7	33.1
28.711	32.5			32.7	
33.414			32.4		
41.861		28.3	33.9		
42.510	27.7	23.7	32.5	30.9	
43.976				32.2	
47.915		30.8	33.0	31.1	
59.324				33.3	34.1
66.789	30.1	29.2	33.4		35.5
68.745	25.9	32.8	36.2	32.1	
69.545					34.0
76.214	34.3	34.9	33.3	32.9	
82.376			36.1		
Number of lines	(12)	(16)	(30)	(17)	(8)
Mean	—28.11	—28.67	—33.67	—31.58	—35.65
Scale Corr.	— .03	— .03	+ .03	.00	+ .08
Systematic Corr.	— .22	— .22	— .22	— .22	— .22
v_s	—28.36	—28.92	—33.86	—31.80	—35.79
Reduction to ⊙	+ 8.24	+ 6.18	+11.22	+ 8.77	+11.13
Observed V	—20.12	—22.74	—22.64	—23.03	—24.66

Mean V = —22.64 km. Mean J. D. 2416849.51

Epoch 1905.01

The velocity of this star is suspected of being variable.

x *Velorum* R. A. 10h 35m3 Dec. — 55° 5′

Magn. 4.4 Type G

Date	1904 Mar. 23.71	1905 Feb. 2.70	1905 Mar. 11.76	1905 Apr. 22.68
Julian day	6563.71	6879.70	6916.76	6958.63
Plate number	260 II	577 II	628 III	706 II
Photographed by	P.	W.	W.	P.
Measured by	P.	P.	P.	P.
λ				
4246.968	+17.7	+ 8.3	+16.1	+25.9
50.287		7.3	13.4	26.2
50.962	16.7	8.3	14.4	25.7
54.505		4.8	14.3	25.4
57.815		4.5		
65.374			13.5	
68.866	21.1	5.3	14.7	27.9
76.836	15.3			
82.565		8.8	16.4	29.5
83.169			12.5	
86.627		5.6		
87.605		5.3		
4313.771	15.2		12.9	
16.962	18.0		16.2	
18.867	21.6	6.7	15.2	27.6
25.195	15.2	4.0	15.2	29.2
25.978	20.9	1.7	14.5	26.9
28.101	14.8	4.4	13.6	28.3
30.866	22.7		17.3	
31.795	20.4	6.1		26.1
37.216	13.8	3.6	14.8	28.8
38.084		4.5		
38.854				27.7
43.402	15.6	8.3	14.6	
47.705	14.0			
49.150	15.9	5.1		
55.294			13.6	
59.784		6.6	14.7	25.8
75.119		7.9	13.7	
76.107	20.2	9.5	14.2	29.4
79.396	16.8	4.7	12.8	24.4
83.720		2.3	12.7	31.2
84.873			18.0	
88.629	14.6	3.9		
89.413	17.2	6.5		25.2
90.118	18.1	4.4	16.2	24.6
99.907	13.8	6.7	12.5	
4404.927		6.2	14.4	28.5
06.810	18.6	3.5	14.6	
10.683	22.3			
17.857	16.6	8.1	17.6	

x *Velorum*—(Continued)

Date	1904 Mar. 23.71	1905 Feb. 2.70	1905 Mar. 11.76	1905 Apr. 22.63
4425.608			18.3	
28.711	13.6	3.0	9.6	
30.785		3.4	12.0	
33.414	20.3			
35.817	15.5	5.7	10.9	
41.861		6.8	13.7	24.6
42.510	19.4	3.9	16.4	24.9
43.976		7.1		28.2
44.728	20.3	6.5		
47.915	17.8	6.0	14.5	25.3
66.727	14.2	8.6	15.7	24.9
68.647	19.2	7.9	17.5	25.9
76.214	20.5	4.4	12.9	25.3
81.364			17.2	
89.911		10.3	21.2	
Number of lines	(34)	(42)	(41)	(27)
Mean	+17.59	+ 5.87	+14.74	+26.79
Scale Corr.	.00	.00	.00	+ .02
Systematic Corr.	— .22	— .22	— .22	— .22
v_s	+17.37	+ 5.65	+14.52	+26.59
Reduction to ⊙	+ 3.37	+14.67	+ 6.67	— 4.88
Observed V	+20.74	+20.32	+21.19	+21.71

Mean V = +20.99 km. Mean J. D. 2416829.70

Epoch 1904.95

u *Carinae* R. A. $10^h\ 49^m4$ Dec. — 58° 19′

Magn. 3.9 Type K

Date	1904 Mar. 11.74	1904 Apr. 21.63	1905 Feb. 19.66	1905 June 14.52
Julian day	6551.74	6592.63	6896.66	7011.52
Plate number	236 II	303 II	601 II	734 II
Photographed by	P	P.	W.	W.
Measured by	P	P.	P.	P.
λ				
4199.267	+ 6.6			
4222.382	— 1.8			
31.183	+ 3.8			
33.772	+ 0.8			
38.970			— 2.8	
41.285	— 0.2			
46.968	+ 1.8	+11.0	2.4	+21.6
50.287	+ 1.2		4.1	21.2
50.962	+ 0.5	11.3	3.9	18.6
54.505		5.9	1.8	21.5
68.866	+ 3.2			24.3
74.935		7.9		
78.39			6.6	
82.127			3.0	
82.565	+ 3.3		1.8	
87.605	— 0.9		5.2	
94.273		10.6	5.1	
4313.771	+ 1.6		1.8	20.1
18.867	+ 3.2	13.3	2.4	19.7
21.00		5.8		
25.195	+ 2.3	13.4	5.6	21.0
25.978			5.9	20.0
28.101	+ 2.1	12.1	4.9	23.4
31.795			6.7	
37.216	+ 0.9	12.6	4.6	20.6
40.634	+ 0.5	13.4	5.0	22.0
41.530			1.4	
43.402				22.1
47.705	+ 6.4			
49.150	+ 0.2			
52.972		12.0	2.3	
55.294			6.9	
59.784	+ 2.7		4.4	19.5
69.924		6.6	2.0	
71.363		14.2		
75.119			0.7	22.8
76.107	— 0.2	15.3	3.2	20.0
79.396	— 1.0	4.9		21.4
83.720			5.1	
90.118	— 1.9		3.2	18.9
91.152			2.8	

u *Carinae*—(Continued)

Date	1904 Mar. 11.74	1904 Apr. 21.63	1905 Feb. 19.66	1905 June 14.52
4395.270		13.6	3.9	
99.907	+ 2.9		7.7	
4404.927		11.7	3.3	23.3
06.810	— 0.3		5.3	
07.850		6.5	6.0	
15.312		15.5	7.3	
28.711	+ 1.3			18.6
30.785			5.6	
33.414	— 1.6			
35.817	+ 0.5		2.3	
41.861			4.4	21.0
42.510	+ 2.4	13.0	2.2	20.9
47.915	+ 0.9	15.5	5.3	20.6
66.789		11.9	5.7	18.2
68.673	+ 6.0	9.0	2.3	24.7
76.214		9.4	4.0	22.2
82.376			4.5	
85.846	+ 2.5			
89.911	+ 3.4			
Number of lines	(33)	(25)	(43)	(26)
Mean	+ 1.61	+11.06	— 4.08	+21.08
Scale Corr.	.00	+ .01	+ .01	— .02
Systematic Corr.	— .22	— .22	— .22	— .22
v_s	+ 1.39	+10.85	— 4.31	+20.84
Reduction to ⊙	+ 8.14	— 2.72	+12.61	—13.97
Observed V	+ 9.53	+ 8.13	+ 8.30	+ 6.87

Mean V = +8.21 km. Mean J. D. 2416763.14

Epoch 1904.77

x *Carinae* R. A. 11h 4m4 Dec. — 58° 26′

Magn. 4.0 Type F8G. Pec.

Date	1904 Jan. 5.83	1904 Apr. 16.69	1905 Jan.6.80	1905 Feb. 24.68	1905 June 21.51	1906 Feb. 24.68
Julian day	6485.83	6587.69	6852.80	6901.68	7018.51	7266.68
Plate number	115 III	293 II	529 II	611 II	737 II	895 II
Photographed by	W	W.	W.	W.	P.	H.D.C.
Measured by	A. M. H.	W.	W.	W.	W.	W.
λ						
4242.53	+ 1		— 6	— 2	+30	+ 8
54.51	+ 1	+17	10	6		
58.33	— 2					
60.65	— 4	10		9		
62.05	— 2	16	6	3	38	+10
84.35	— 3	18	7	2	32	+ 4
4308.06	+ 7					
13.034			12	6		+ 7
18.817		14	5	3	32	+ 2
20.99	— 2		6	7	32	+ 6
28.101		19	6	8		— 2
40.61	—10					
44.45	— 3		7		36	+ 6
76.101		17	10	3	32	+ 6
83.71	+10					
4404.91	+ 3	16	5	7	27	+ 7
25.608			7		25	+ 8
50.66	+ 7		8	3		+14
64.64	+ 2			5	32	+ 4
66.72		11		7		
81.39	—14					
82.376				5		
4508.45	— 8		9	4	30	0
15.52	— 9		11	6	25	— 1
20.38	—11		13	8		
22.78	+ 1		7		33	
49.72	+ 9					
Number of lines	(20)	(9)	(17)	(18)	(13)	(15)
Mean	— 1.3	+15.3	— 7.9	— 5.2	+31.1	+ 5.3
Scale Corr.					— 0.1	
Systematic Corr.	— .2	— .2	— .2	— .2	— .2	— .2
V_s	— 1.5	+15.1	— 8.1	— 5.4	+30.8	+ 5.1
Reduction to ☉	+16.7	— 0.7	+16.7	+12.6	—15.0	+12.7
Observed V	+15.2	+14.4	+ 8.6	+ 7.2	+15.8	+17.8

Velocity variable.

On account of the hazy character of the lines in this spectrum the measurements are subject to considerable uncertainty. The variability of the velocity was strongly suspected from these measurements however, and it was confirmed by observations kindly made for thepurpose by Dr. Curtis and Mr. Paddock. Their observations are as follows:

1907.	March	5.801	+4.5 km.
	April	27.636	+3.3
	May	13.568	+3.7

y Carinae R. A. $11^h\ 8^m3$ Dec. — 59° 46′

Magn 4.7 Type F5G. Pec.

Date	1904 Mar. 13.76	1905 Jan. 31.74	1905 Feb. 25.67
Julian day	6553.76	6877.74	6902.67
Plate number	242 II	573 III	613 II
Photographed by	P.	W.	W.
Measured by	A. M. H.	W.	W.
λ			
4242.53	—19		
46.99	17		
58.33	24	—23	—23
62.05	11		
84.35	22		
90.41		24	29
4300.211		15	24
02.08		19	26
08.06	9		
13.034		23	27
20.99	18	27	24
38.084		19	25
51.96	14		
83.71	10	23	19
95.21	13		
4404.91	11		
43.976		12	20
50.66	19	22	22
64.64	29	20	27
68.647		15	20
81.39	19	21	23
4501.45	18	19	24
08.45	19	20	21
15.52	18	23	24
20.38	21	21	24
34.19	18		
49.72	16		
72.15	14		
Number of lines	(21)	(17)	(17)
Mean	—17.1	—20.4	—23.6
Scale Corr.	0.0	+ 0.1	+ 0.1
Systematic Corr.	— .2	— .2	— .2
v_s	—17.3	—20.5	—23.7
Reduction to ☉	+ 9.0	+16.0	+12.7
Observed *V*	— 8.3	— 4.5	—11.0

Mean *V* = —7.9 km. Mean J. D. 2416778.06

Epoch 1904.81

The lines in the spectrum of this star are broad and diffuse, and the radial velocity determinations are therefore subject to great uncertainty. Nevertheless it is believed that the range in value of about six kilometers in the observed velocities affords a strong indication of actual variation. The following additional observation has been secured by Mr. Paddock at the Chilean station.

Date	Velocity	Measured by
1907 May 14.584	— 8.1	Pk.

ξ Hydrae R. A. 11^h 28^m1 Dec. — 31° 18′

Magn. 3.7 Type G5K

Date	1904 Jan. 8.81	1904 Feb. 3.72	1905 Jan. 5.82	1905 Mar. 16.64
Julian day	6488.81	6514.72	6851.82	6921.64
Plate number	118 II	164 IV	524 III	641 II
Photographed by	W.	W.	W.	P.
Measured by	W.	R. H. C.	P.	P.
λ				
4238.970			—30.0	
46.968	—30.3		29.9	— 9.2
50.287	31.8	—26.6	32.1	10.7
50.962	29.3		29.5	8.8
54.505	32.3	27.0	32.3	10.7
57.815				11.2
65.374			26.5	
67.543		26.1		
68.866				9.1
74.935	30.0		30.1	
82.565	27.6	23.9	25.2	8.3
83.169		28.0	34.2	
84.382			35.2	
86.627				9.5
90.377			24.0	
96.735			28.1	
4313.034			33.0	
13.771	28.7		30.7	9.6
18.867	27.7		30.5	9.3
25.195	31.6		31.3	
25.978			29.5	
28.101	29.0	26.1	29.6	10.9
30.189				8.1
31.795		22.2	32.7	
37.216	27.8	30.2	31.2	11.7
40.634	29.0	22.6	31.7	8.8
41.530		25.2	27.4	
49.150	27.2	30.7		9.2
51.93			26.0	
55.294				7.4
59.784	25.3	27.2	34.8	7.4
69.924	26.8			
71.363			30.6	
75.119			29.0	9.3
76.107	23.9		27.3	8.2
79.396		29.8	30.8	6.8
83.720		25.2		
87.007			27.6	
88.629			28.4	
90.118			30.8	9.0
91.152	26.3		29.0	

A. G.C. 16100 R. A. 11^h 41^m7 Dec. — 60° 37′
Magn. 4.2 Type G

Date	1904 Jan. 18.79	1904 May 15.60	1905 Feb. 23.84	1905 Apr. 1.71
Julian day	6498.79	6616.60	6900.84	6937.71
Plate number	137 III	320 II	610 IV	671 II
Photographed by	P.	W.	W.	P.
Measured by	P.	W.	P.	P.
λ				
4222.382	—19.6			
33.772	23.2			
38.970			—18.5	
46.968			19.0	—10.0
50.287	21.1		19.4	11.4
50.962	16.6		19.0	10.0
54.505	19.2		18.7	9.1
57.815			20.8	
60.640			14.2	6.9
65.374			15.8	
82.565	18.7		18.1	10.0
83.169		— 0.9		
87.605			20.7	14.7
4300.211			17.3	
13.771			17.9	10.0
18.867				9.7
25.195	20.5		19.9	
25.978		+ 2.2	18.9	8.0
28.101			17.8	14.1
31.795	22.7		17.8	
37.216	20.5		17.1	9.3
38.084			22.0	
40.634			13.4	5.7
41.530				12.5
46.725			15.6	
52.949		+ 4.8		
59.784		+ 7.2	17.9	12.0
66.061				8.0
75.119		+ 3.9	17.4	8.2
76.107	22.5	+ 2.0	19.3	8.0
79.396				11.8
83.720			18.1	10.0
88.629				11.5
90.118	20.0		19.4	7.7
95.270		+ 3.0		
99.907	22.5		20.3	
4404.927	22.5	+ 3.6	16.9	11.4
06.810	25.5		20.3	11.3
07.850		+ 1.1		
17.857	22.9		19.5	6.5
25.608				5.0

A.G.C. 16100—(Continued)

Date	1904 Jan. 18.79	1904 May 15.60	1905 Feb. 23.84	1905 Apr. 1.71
4427.444		+ 2.6		
28.711	17.3	+ 1.0		
30.785	18.0		17.3	
33.414			21.5	
35.817	17.6		15.5	
37.718	17.9			
41.861	21.3		20.4	14.7
42.510	19.0		19.5	9.3
43.976			19.3	13.7
47.915	18.5	+ 9.1	18.0	11.2
51.752	16.7			
66.727	22.3	+ 6.4	14.6	12.3
68.647	20.3	+ 2.6	18.7	11.3
69.545		+ 5.5		
76.214		+ 1.1	18.8	12.2
85.846	20.4	+ 8.4	17.1	
4501.445	19.7			
05.003	23.9			
28.798		+ 2.4		
Number of lines	(28)	(18)	(40)	(33)
Mean	—20.39	+ 3.67	—18.30	—10.23
Scale Corr.	+ .03	.00	+ .02	— .02
Systematic Corr.	— .22	— .22	— .22	— .22
v_s	—20.58	+ 3.45	—18.50	—10.47
Reduction to ⊙	+17.52	— 6.33	+14.71	+ 6.31
Observed V	— 3.06	— 2.88	— 3.79	— 4.16

Mean V = —3.47 km.

Mean J. D. 2416738.48
Epoch 1904.70

η Crucis R. A. $12^h\ 1^m 7$ Dec. — 64° 3′

Magn. 4.3 Type F

Date	1904 Jan. 25.81	1905 Jan. 15.81	1905 Mar. 14.64	1905 May 24.58
Julian day	6505.81	6861.81	6919.64	6990.58
Plate number	149 III	540 III	635 II	726 II
Photographed by	P.	W.	P.	P.
Measured by	W.	W.	W.	W.
λ				
4260.65	—10	—13	— 9	+ 6
4308.06	—12	— 9	— 7	+ 7
20.99	+ 2	— 3	— 7	+21
40.61	— 1	— 3	— 2	+25
51.96	— 9		— 8	
83.71	—11	—18	— 7	
4404.91	— 3	— 7	+ 9	+11
64.64			+ 1	
81.375	+ 4	— 2	+ 4	+31
4501.45	— 1	— 7	+ 8	+30
08.45			0	
22.78			+ 4	+30
34.19	—19			+14
49.72	— 4	—11	— 2	+29
72.15		— 1	+ 4	
Number of lines	(11)	(10)	(14)	(10)
Mean	— 5.8	— 7.4	— 1.0	+20.4
Scale Corr.	0.0	0.0	0.0	0.0
Systematic Corr.	— .2	— .2	— .2	— .2
v_s	— 6.0	— 7.6	— 1.2	+20.2
Reduction to ⊙	+17.1	+16.7	+12.4	— 6.6
Observed V	+11.1	+ 9.1	+11.2	+13.6

Mean $V = +11.2$ km. Mean J. D. 2416819.46

Epoch 1904.92

The lines in this spectrum are very diffuse and difficult of measurement.

ε Corvi R. A. $12^h\ 5^m0$ Dec. $-22°\ 3'$

Magn. 3.2 Type K

Date	1904 Feb. 4.75
Julian day	6515.75
Plate number	166 III
Photographed by	W.
Measured by	P.
Number of lines	(29)
Mean	—19.36
Scale Corr.	+ .01
Systematic Corr.	— .22
v_s	—19.57
Reduction to ⊙	+23.76
Observed V	+ 4.19

Mean $V = +4.19$ km.

J. D. 2416515.75

Epoch 1904.10

As only one observation of this star was secured the measurements of the individual lines are not given. Mt. Hamilton observations secured with the Mills spectrograph are as follows:

Date	Velocity
1897.26	+4.4
1899.37	4.5
1901.35	5.0
1903.34	5.6
1906.34	4.9
Mean 1901.53	+4.9

Magn. 4.2 R. A. $12^h\ 12^m1$ Dec. — 67° 24′

ε Muscae Type Mb

Date	1905 Jan. 29.77	1905 Feb. 10.76	1905 Apr. 6.73
Julian day	6875.77	6887.76	6942.73
Plate number	568 II	592 III	687 III
Photographed by	W.	W.	W.
Measured by	P.	P.	W.
λ			
4238.970		— 4.7	
46.968	— 5.9		
50.287	6.6	6.6	
50.962	10.2	12.0	
60.640	10.5		
65.320	11.1	9.2	
68.866	9.4		
4300.211	15.0		
00.732	11.4		
18.867	7.6		
25.195		6.0	— 1.4
25.978	13.3	11.5	
30.189	6.9		
31.795			+ 5.0
32.921	8.1		
37.216	12.1	11.0	— 0.7
40.634	10.7	9.5	
46.725		14.5	
49.150	11.8		+ 1.8
53.008			— 0.8
55.294		14.2	
59.784	7.9	7.3	+ 1.8
69.924			— 3.3
75.119	8.2	9.3	— 4.1
76.107	6.4	9.4	+ 0.4
79.396	7.5		— 4.9
83.720	8.9	13.2	+ 2.3
84.873	2.8		
89.413	9.4		
90.168	10.3	7.6	
91.152		10.7	— 2.7
95.298		9.1	— 2.5
4404.927			+ 5.4
06.810	9.0	8.4	— 2.3
07.850		12.6	— 4.3
25.608	5.0	10.3	
27.444			— 1.6
28.711	14.4		— 2.0
41.861	10.1	9.1	— 0.8
42.510	8.3	8.3	+ 2.8
47.915	8.7	7.5	

ε Muscae—(Continued)

Date	1905 Jan. 29.77	1905 Feb. 10.76	1905 Apr. 6.73
4466.789	10.3	9.4	
68.745	11.2	9.2	
76.214	11.4	11.6	
82.376		14.7	
89.911	3.4		
Number of lines	(33)	(27)	(20)
Mean	— 9.21	— 9.89	— 0.60
Scale Corr.	.00	+ .01	.00
Systematic Corr.	— .22	— .22	— .22
v_s	— 9.43	—10.10	— 0.82
Reduction to ⊙	+16.42	+16.38	+ 7.89
Observed V	+ 6.99	+ 6.28	+ 7.07

Mean V = +6.78 km. Mean J. D. 2416902.09

Epoch 1905.15

ε Crucis R. A. $12^h\ 15^m9$ Dec. — 59° 51′

Magn. 3.6 Type K2M

Date	1904 Jan. 28.81	1904 Mar. 12.79	1905 Jan. 20.81	1905 Mar. 29.64
Julian day	6508.81	6552.79	6866.81	6934.64
Plate number	156 II	239 II	553 III	664 II
Photographed by	W.	P.	W.	W.
Measured by	W.	P.	P.	P.
λ				
4233.772				—14.7
38.980		—15.2	—19.9	
39.525				16.8
43.981			26.4	
46.968		23.2	22.0	12.5
50.287		18.1	20.0	13.0
50.962		22.2	19.6	14.5
58.50		16.1		
65.374			22.3	13.1
68.866				13.6
76.836		18.6	21.8	
78.39			21.6	
82.565				8.8
83.169			22.2	
86.627				13.8
87.605		18.2		14.1
94.273		15.0		
4313.771			28.0	15.5
16.962				9.4
18.867		17.6	21.8	14.2
25.195			23.9	13.5
28.101	—24.4	14.6	23.2	13.0
30.189				9.7
31.795		15.1	21.7	15.5
37.216		15.4	24.7	13.4
37.725				13.0
40.634		19.3	25.4	12.5
41.530		20.0		
47.464				17.8
49.150				14.5
52.990	23.5	14.0		
55.294			22.6	13.5
59.784			21.8	13.1
69.924	24.6	19.3	22.8	
75.119	24.3		20.9	11.8
76.107	19.8	12.8	24.3	11.8
79.396	26.3	17.4	23.5	17.5
87.007		15.2	24.1	
89.413				12.0
90.143			24.2	15.3
91.152	21.7	20.2	24.2	
95.298		17.4		

ε *Crucis*—(Continued)

Date	1904 Jan. 28.81	1904 Mar. 12.79	1905 Jan. 20.81	1905 Mar. 29.64
4404.927		21.2		
06.810	21.8	18.6	25.5	15.4
07.850	25.0	18.1	24.9	
18.542		15.8		
27.444	22.3			
28.711	21.1			16.2
30.785				17.6
35.817	23.8			17.0
41.861	22.7	23.8	25.9	14.1
42.510	19.9	16.5	23.1	13.6
43.976			22.3	13.1
47.915	22.9	15.8	26.2	14.0
51.752				11.9
59.324	22.5			
66.789	23.4	11.1	20.9	16.5
68.745	22.6	17.7		15.6
76.211	26.6	18.8	24.5	13.9
82.376		15.5	23.6	
Number of lines	(19)	(32)	(34)	(41)
Mean	—23.11	—17.43	—23.23	—13.92
Scale Corr.	— .11	+ .01	+ .11	— .01
Systematic Corr.	— .22	— .22	— .22	— .22
v_s	—23.44	—17.64	—23.34	—14.15
Reduction to ⊙	+18.98	+13.33	+18.89	+ 9.15
Observed V	— 4.46	— 4.31	— 4.45	— 5.00

Mean V = —4.56 km.

Mean J. D. 2416715.76
Epoch 1904.64

γ Crucis R. A. $12^h\ 25^m6$ Dec. — 56° 33′

Magn. 1.6 Type Mb

Date	1904. Jan. 9.85	1904 Feb. 7.74	1905 Jan. 8.84	1905 Apr. 4.60
Julian day	6489.85	6518.74	6854.84	6940.60
Plate number	119 IV	175 II	531 III	680 II
Photographed by	W.	E. L. W.	W.	W.
Measured by	R. H. C.	W.	P.	P.
λ				
4238.970			— 0.6	
39.525				+ 9.5
41.287				11.4
46.968			+ 1.2	13.1
50.287	+ 3.0		+ 4.6	10.3
50.962			+ 1.3	13.7
57.815				15.4
65.320	+ 3.5		+ 3.7	14.5
68.866	— 0.2			13.9
82.565	— 0.8			
83.169			+ 3.0	
86.627				13.8
87.605			+ 3.0	13.8
91.630			+ 0.5	
4300.211	+ 0.2			18.4
00.732	+ 2.9		— 1.1	12.6
18.867	— 1.8	— 0.9		
25.195			+ 1.8	15.4
25.978			+ 2.9	
28.101	— 2.1		+ 1.1	11.1
30.189				15.0
31.795		— 1.8	+ 6.6	19.2
32.921				15 8
37.216	+ 1.8		0.0	11.6
37.725	— 1.3		+ 3.7	15.3
40.634	+ 3.8		— 0.5	15.8
41.167				16.5
43.861	+ 0.9			
46.725			+ 1.6	
47.464				13.0
49.150		— 1.1		
55.294			+ 3.4	
59.784		+ 2.2	+ 5.9	16.2
66.061				13.9
69.924		0.0	— 0.1	12.7
71.363			+ 2.3	
75.119			+ 1.9	13.1
76.107	+ 1.9	0.0	+ 3.6	12.9
79.396	+ 3.2	— 0.7	+ 2.8	13.3
83.720			+ 0.2	13.5
89.413	+ 2.7			13.6

γ *Crucis*—(Continued)

Date	1904 Jan. 9.85	1904 Feb. 7.74	1905 Jan. 8.84	1905 Apr. 4.60
4390.168			+ 2.3	14.4
91.152		0.0	+ 3.5	
95.298		— 2.8		
4404.927				12.6
06.810	+ 2.4	+ 0.4	+ 3.1	14.2
07.850		0.0	+ 1.6	
11.240	+ 0.4		+ 5.1	
16.985	+ 2.8			
17.857			+ 4.2	
18.542	+ 0.2		+ 2.3	
25.608	+ 5.2			
27.444		+ 1.2		
28.711				11.0
35.817	— 0.5		+ 0.1	13.8
41.861		— 2.8	+ 3.9	12.3
42.510	— 0.2	+ 2.0	+ 5.5	12.6
43.976	+ 1.2			
47.915	+ 1.3	+ 1.2	+ 2.7	11.5
50.654			— 3.1	
51.752				13.7
55.485				14.4
66.789			+ 3.7	11.7
68.745			+ 1.5	12.8
76.214			+ 0.2	11.4
82.376			— 3.6	
Number of lines	(24)	(15)	(41)	(43)
Mean	+ 1.27	— 0.20	+ 2.09	+13.60
Scale Corr.	.00	.00	— .01	.00
Systematic Corr.	— .22	— .22	— .22	— .22
v_s	+ 1.05	— 0.42	+ 1.86	+13.38
Reduction to ⊙	+19.55	+19.79	+19.53	+ 7.50
Observed V	+20.60	+19.37	+21.39	+20.88

Mean $V = +20.56$ km. Mean J. D. 2416701.01

Epoch 1904.61

β Corvi R. A. $12^h\ 29^m1$ Dec. — 22° 50′

Magn. 2.8 Type G5K

Date	1905 Jan. 26.81	1905 Feb. 20.86	1905 Mar. 17.66	1905 Apr. 16.69
Julian day	6872.81	6897.86	6922.66	6952.69
Plate number	561 IV	604 III	644 II	699 III
Photographed by	W.	W.	P.	P.
Measured by	P.	P.	P.	P.
λ				
4231.183	—38.3			
33.328	36.1			
33.772	35.2		—18.1	
38.188	39.5	—29.6		
39.525				— 3.6
46.968	34.3	26.6	16.5	— 1.5
50.287	35.1	28.8	17.9	— 4.1
50.962	36.0	28.7	14.9	— 2 6
54.505	35.0	26.9	15.1	— 3.3
57.815		26.9		— 2.2
60.640	30.3	23.7		
63.290				+ 1.1
65.374	35.3	24.0	10.7	+ 1.6
68.866	31.8	25.3	16.2	— 3 4
82.565	33.2	23.6	11.1	— 2.2
83.169		32.7		— 3.7
86.627	33.9	23.7	12.8	— 2.0
87.605	35.6	26.7	19.6	— 2.7
4300.211	31.8		15.4	
03.337				— 2.5
13.034	35.6			
13.771	33.1	29.3		— 6.3
16.962		23.7	15.0	
18.867	34.2	27.4	17.3	— 3.2
25.195	34.8	28.7	19.4	— 4.0
25.978	36.1	27.9	17.1	— 1.8
28.101	35.2	27.6	17.1	— 1.9
30.866	30.3			
31.795	36.4	28.3		— 2.6
37.216	34.7	25.6	14.2	— 4 3
37.725	37.9			
38.084	36.3			— 2.5
38.854	33.1			+ 1.4
40.634	30.8	26.0	15.9	— 1.6
41.530	35.3	23.6		— 4.3
49.150	34.4			— 2.4
55.294	38.6	27.9	15.3	
59.784	33.5	25.6	17.1	— 2 2
69.924	34.5			
75.119		27.5	18.3	— 4.7
76.107	33.4	24.3	15.0	— 1.7

β Corvi—(Continued)

Date	1905 Jan. 26.81	1905 Feb. 20.86	1905 Mar. 17.66	1905 Apr. 16.69
4379.396	35.2	28.0	17.5	— 3.9
83.720	36.1	27.6	15.7	— 3.0
84.873			10.1	
88.629		31.6		— 5.0
89.413	37.8	27.1	13.9	— 3.1
90.118	35.5	25.8	16.4	— 3.6
99.907	36.9	26.5	17.4	— 3.3
4404.927	34.5	25.6	16.1	— 2.3
06.810	36.1	27.9	18.9	— 4.7
17.857	33.7	26.2	15.3	0.0
28.711	38.8	26.6		— 5.2
30.785	34.6	26.6		— 2.0
35.817	34.7	25.4	16.0	— 2.5
41.861	37.5	27.3	12.5	— 6.2
42.510	35.1	26.8	14.4	— 3.2
43.976	35.9	27.9	16.1	— 4.1
47.915	35.3	27.5	17.1	— 5.1
51.752			17.4	
66.727	37.2	28.4	15.0	— 3.1
68.673	36.1	25.9	16.3	— 3.3
76.214	35.7	30.2	17.3	— 2.7
81.364				— 0.2
85.846		30.5		
89.911		32.1		— 3.4
Number of lines	(52)	(48)	(40)	(50)
Mean	—35.12	—27.13	—15.84	— 2.86
Scale Corr.	+ .02	.00	— .01	— .01
Systematic Corr.	— .22	— .22	— .22	— .22
v_s	—35.32	—27.35	—16.07	— 3.09
Reduction to ⊙	+27.07	+19.64	+ 9.91	— 4.77
Observed *V*	— 8.25	— 7.71	— 6.16	— 7.86

Mean *V* = —7.50 km. Mean J. D. 2416911.50

Epoch 1905.18

β Crucis R. A. $12^h\ 41^m8$ Dec. — 59° 8′

Magn. 1.5 Type B1A

Date	1904 Mar. 7.73	1905 Jan. 14.86	1905 Jan. 15.87	1905 July 17.45	
Julian day	6547.73	6860.86	6861.87	7044.45	
Plate number	221 III	538 II	541 IV	743 II	
Photographed by	W.	W.	W.	P.	
Measured by	W.	P.	A.	W.	A.
λ					
4253.821		— 3.6	—13.0		+22.6
67.280		— 7.0	3.7	+24.3	20.2
4317.302		+ 2.8	5.9		
19.774		— 8.8	5.5		22.8
40.634	+ 6.4	—17.4	10.9	21.4	23.2
45.725		—11.0			26.6
49.560		— 9.8	1.1		
51.426		—12.7	6.5		
67.023		— 2.6			
88.100	— 5.3	— 7.4	7.2	24.3	27.2
4415.035		— 6.5	2.2		25.6
17.129		— 4.8	8.9		29.0
37.718		— 0.2			
48.322			4.2		
71.693	+ 5.2	— 8.9	7.4	29.0	30.5
81.375		—16.3	13.5		32.5
Number of lines	(3)	(15)	(13)	(4)	(10)
Mean	+ 2.1	— 7.61	— 6.92	+24.8	+26.02
Scale Corr.	.0	+ .03	+ .02	.0	— .05
Systematic Corr.	— .2	— .22	— .22	— .22	
v_s	+ 1.9	— 7.80	— 7.12	+25.2	
Reduction to ⊙	+16.06	+19.29	+19.36	—18.72	
Observed V	+18.0	+11.49	+12.24	+ 6.5	
Velocity variable.				Mean J. D. 2416828.73	
				Epoch 1904.95	

The variation in velocity indicated by the above measures is confirmed by others secured later at Santiago. These are:

Date	Velocity	Measured by
1907 Apr. 30.658	+13	Pk.
May 6.547	+25	H.D.C.
May 16.543	+14	Pk.
July 1.478	+20	H.D.C.
1909 Jan. 26.817	+14	H.D.C.

δ Muscae R. A. $12^h\ 55^m.4$ Dec. — 71° 0′

Magn. 3.6 Type K2M

Date	1904 Feb. 8.79	1904 Mar. 24.79	1905 Jan. 28.82	1905 Apr. 2.62
Julian day	6519.79	6564.79	6874.82	6938.62
Plate number	179 II	263 II	567 III	674 II
Photographed by	P.	P.	W.	P.
Measured by	P.	P.	P.	P.
λ				
4239.525			+18.6	
41.287			18.4	+22.9
46.968		+23.5	21.1	25.7
50.287		22.5	23.1	21.6
50.962		27.1	19.0	20.1
57.815			18.9	
63.290		27.1	23.5	
65.374		25.4		28.2
68.866		24.1	22.4	24.8
82.127		26.7		
82.565		25.4		27.2
83.169		24.4		
86.627		25.2	22.1	22.9
87.605		21.2	21.3	21.8
4303.337				24.3
13.771		22.7	20.3	
16.962	+24.8		22.1	
18.867	20.6	22.9	20.3	24.8
25.195				22.9
25.978				20.5
28.101	17.8	23.4	19.4	25.7
30.189			20.5	22.7
31.795			16.5	
37.216	16.2	23.6	19.0	23.5
40.634		18.3	18.6	19.5
41.530	14.5			
43.402		23.4		
46.725	23.3			
47.464		20.0	18.1	
47.705		25.8		
49.150		21.9	20.1	22.1
59.784	16.5	25.3	20.2	23.7
66.061		24.8		25.0
75.119		20.5	20.6	21.3
76.107	12.9	20.4	20.9	21.7
79.396	17.4	20.0	20.5	19.7
89.413	17.5	25.0		27.3
90.143	16.1	18.4	17.8	21.6
4406.810	16.1	26.0	19.1	22.6
28.711	20.1	23.6	19.4	23.2
30.785	11.5	20.8	19.4	18.8

δ *Muscae*—(Continued)

Date	1904 Feb. 8.79	1904 Mar. 24.79	1905 Jan. 28.82	1905 Apr. 2 62
4435.817	19.1	21.8	20.2	24.0
38.006		18.6	14.5	19.6
41.861	15.8	19.4	21.8	27.9
42.510	20.6	22.3	19.7	23.8
43.976		23.0	18.8	23.7
47.915	17.8	22.9	20.4	23.3
66.789	13.9	20.7	18.8	19.6
68.745	14.9	21.9	16.5	20.4
70.648	19.0			
76.214	19.8	22.7	18.1	21.5
89.911	22.5	23.6		24.8
Number of lines	(23)	(40)	(37)	(38)
Mean	+17.77	+22.91	+19.73	+23.02
Scale Corr.	— .03	.00	.00	+ .02
Systematic Corr.	— .22	— .22	— .22	— .22
v_s	+17.52	+22.69	+19.51	+22.82
Reduction to ⊙	+16.48	+12.75	+15.93	+11.21
Observed V	+34.00	+35.44	+35.44	+34.03

Mean $V = +34.73$ km. Mean J. D. 2416724.50

Epoch 1904.67

ι Centauri R. A. 13^h 15^{m}0 Dec. — 36° 11′

Magn. 2.9 Type A2F

Date	1904 Apr. 10.74	1905 Jan. 16.85	1905 Mar. 16.73	1905 Apr. 28.68
Julian day	6581.74	6862.85	6921.73	6964.68
Plate number	290 III	544 III	642 III	721 III
Photographed by	P.	W.	P.	W.
Measured by	A.	A.	A.	A.
λ				
4340.634	+10 wt. ⅓	—29.5	—24.2 wt. ½	+ 2.5 wt. ½
4481.375	—14	—28.8	— 6.8	+ 9.3
Number of lines	(2)	(2)	(2)	(2)
Mean	— 8.	—29.2	—12.6	+ 7.0
Scale Corr.	0.	+ 0.1	.0	.0
Systematic Corr.	— .2	— .2	— .2	— .2
v_s	— 8.	—29.3	—12.8	+ 6.8
Reduction to ⊙	+ 5.40	+27.21	+16.18	— 2.62
Observed V	— 3.	— 2.1	+ 3.4	+ 4.2

Mean V = +0.6 km. Mean J. D. 2416832.75

Epoch 1904.96

The plate No. 290 III is underexposed and very poor.

d *Centauri* R. A. $13^h\ 25^m2$ Dec. — 38° 54′

Magn. 4.0 Type K

Date	1904 Apr. 21.74	1904 May 12.55	1905 Feb. 14.79	1905 Mar. 30.65
Julian day	6592.74	6613.55	6891.79	6935.65
Plate number	304 III	315 II	597 III	668 II
Photographed by	P.	W.	W.	W.
Measured by	P.	P.	P.	P.
λ				
4222.382				—12.5
41.287			—28.3	14.5
46.968	— 7.9			14.9
50.287	— 1.9		26.9	16.3
50.962			27.0	15.6
54.505			29.6	13.8
55.134				16.3
57.815				16.2
65.374			26.2	
68.866			24.9	14.4
87.605			29.1	
4313.034				14.9
18.867	— 3.9		26.9	
25.978				11.5
28.101	— 6.0	— 0.5	28.2	13.5
30.866				12.7
31.795	— 4.5	+ 1.3	26.2	15.7
32.921			30.6	
37.216	— 5.1		23.5	14.6
47.464			26.5	
47.705		+ 3.6		
49.150		+ 0.2	28.4	
55.294				17.0
59.784		+ 5.3	27.6	15.6
69.924	— 3.4			
75.119			27.3	15.1
76.107		+ 2.7	24.9	15.7
79.396	— 4.7	— 2.0	31.6	16.7
83.720			27.2	
89.413			26.2	13.0
90.118			27.9	13.2
99.907	— 4.9	+ 8.2	28.8	13.5
4404.927			27.7	12.6
06.810	+ 0.5		29.6	14.0
17.857	— 9.6	+ 2.6	30.7	13.2
28.711	— 6.0	+ 2.1	28.8	16.4
30.785			30.0	13.6
32.736			28.1	11.5
33.414	— 7.9	+ 6.0		
35.817			29.8	13.6
38.006		30.7		

d *Centauri*—(Continued)

Date	1904 Apr. 21.74	1904 May 12.55	1905 Feb. 14.79	1905 Mar. 30.65
4441.861		+ 1.3	27.9	14.7
42.510	— 5.6	+ 3.5	28.8	12.8
43.976				14.9
47.915	— 4.2	+ 0.3	28.3	12.4
66.789	— 6.9	— 0.1	27.4	
68.673	— 3.9	+ 3.6	29.2	16.0
76.214			31.2	17.9
82.376	0.0	+ 3.2		
84.392		+ 0.6		
89.911			23.1	
Number of lines	(18)	(18)	(37)	(36)
Mean	— 4.77	+ 2.33	—27.98	—14.47
Scale Corr.	.00	.00	+ .01	— .01
Systematic Corr.	— .22	— .22	— .22	— .22
v_s	— 4.99	+ 2.11	—28.19	—14.70
Reduction to ⊙	+ 1.88	— 7.31	+25.18	+11.86
Observed V	— 3.11	— 5.20	— 3.01	— 2.84

Mean V = —3.54 km.

Mean J. D. 2416758.43
Epoch 1904.76

ν Centauri R. A. $13^h\ 43^m5$ Dec. — 41° 12′

Magn. 3.5 Type B2A

Date	1904 Apr. 20.58	1905 Jan. 25.83	1905 Mar. 18.78	1905 Apr. 3.79	1905 Apr. 13.65	1905 Apr. 27.69
Julian day	6591.58	6871.83	6923.78	6939.79	6949.65	6963.69
Plate number	302 II	558 IV	648 III	678 III	692 III	717 III
Photographed by	P.	P.	P.	W.	P.	P.
Measured by	W.	W.	W.	P.	P.	W.
λ						
4267.280	—14 wt. ½		+15		+28	— 3 wt. ½
4340.634	9 wt. ½	—22	8	+ 2	25	0
88.100	24	20	10	— 6	23	+ 1
4437.718		23				
71.693	19	26	2	— 7	21	0
Number of lines	(4)	(4)	(4)	(3)	(4)	(4)
Mean	—18.2	—22.8	+ 8.8	— 3.6	+24.2	— 0.1
Scale Corr.	0.0	0.0	0.0	0.0	0.0	0.0
Systematic Corr.	— .2	— .2	— .2	— .2	— .2	— .2
r_s	—18.4	—23.0	+ 8.6	— 3.8	+24.0	— 0.3
Reduction to ☉	+ 4.8	+26.7	+17.8	+11.8	+ 7.9	+ 1.6
Observed *V*	—13.6	+ 3.7	+26.4	+ 8.0	+31.9	+ 1.3

Velocity variable.

μ Centauri R. A. $13^h\ 43^m.6$ Dec. — 41° 59′

Magn. 3.3 Type B2A Pec.

Date	1904 Mar. 8.85	1905 Jan. 14.83	1905 Apr. 8.75	1905 July 18.48
Julian day	6548.85	6860.83	6944.75	7045.48
Plate number	226 III	537 IV	690 IV	744 II
Photographed by	P.	W.	W.	P.
Measured by	W.	W.	W.	W.
λ				
4340.634 (Hγ)	— 5.0±	—14.3±	— 0.7±	+38.7±
Scale Corr.	0.0	0.0	0.0	0.0
Systematic Corr.	— 0.2	— .2	— .2	— .2
v_s	— 5.2	—14.5	— 0.9	+38.5
Reduction to ⊙	+20.0	+25.7	+ 9.9	—24.9
Observed *V*	+14.8	+11.2	+ 9.0	+13.6

Mean *V* = +12.2 km. Mean J. D. 2416849.98

Epoch 1905.01

Bright, rather broad Hγ and Hδ superimposed on broad, dark lines. The measurements for radial velocity were made on the center of the bright Hγ line. On three of the plates a fine absorption line in the exact center of the bright Hγ line is strongly suspected. The width of this bright line is about 2.6 Angströms.

ν^2 Centauri R. A. $13^h\ 55^m4$ Dec. — 45° 7′

Magn. 4.4 Type F5G

Date	1904 Apr. 6.66		1904 May 16.57	1905 Mar. 15.73	1905 Apr. 4.68	1906 Jan. 22.84
Julian day	6577.66		6617.57	6920.73	6940.68	7233.84
Plate number	279 I		323 III	639 IV	681 III	871 IV
Photographed by	P.		W. & P.	W.	W.	W.
Measured by	W.	P.	W.	P.	W.	W.
λ						
4238.970				—28.7		
46.968				28.1	—20.5	—23.7
50.287				29.7	21.6	24.5
50.945				26.8	19.5	22.0
54.505				26.2	20.2	23.4
74.935				22.9	18.4	23.7
78.390					23.8	25.7
82.565	—11.7	—13.5		28.7	19.6	22.2
83.169	6.1	5.4		28.4	21.9	23.9
4300.211				25.8	18.0	20.1
03.337				26.7	20.9	22.0
13.034		11.8	+ 9.1	26.6	20.8	20.8
18.867		7.8		27.6		
25.195	9.7	12.7		29.7	24.2	23.5
25.939	1.5	3.6	13.2	27.9	18.4	22.5
37.216				26.2		19.3
38.084					18.9	23.9
40.634				21.8		
52.949		11.2	6.2	29.1		
59.784			14.7			
76.107	12.8	15.3	7.1	25.8	19.8	25.1
83.720	2.5	6.4	10.7	28.0	20.0	21.2
87.007				27.0		
91.152				29.2		24.0
95.242	11.1	11.1		30.4	19.3	25.8
99.907		10.9	10.8	27.0	17.4	22.8
4404.925	3.6	6.6	12.0	27.5	21.0	21.3
07.850				28.3	20.7	
16.985	16.0	12.2		27.4		
17.857			11.4	28.0		
25.608	8.9				20.3	23.9
27.444					23.1	21.5
30.785			10.8			
35.817		4.0		28.1		21.4
41.861		4.1		25.8		20.2
43.976				26.6		21.2
47.918			10.3	25.8		
50.654	5.5			24.1		
66.727				28.6		
68.647		8.6		25.2		

ν^2 *Centauri*—(Continued)

Date	1904 Apr. 6.66		1904 May 16.57	1905 Mar. 15.73	1905 Apr. 4.68	1906 Jan. 22.84
4476.214	10.9	6.4	3.6	28.5		
82.376				29.1		
Number of lines	(12)	(17)	(12)	(36)	(22)	(26)
Mean	— 8.4	— 8.9	+10.0	—27.26	—20.38	—22.68
Scale Corr.	0.0	0.0	0.0	+ 0.01	+ 0.03	+ 0.07
Systematic Corr.	— 0.2		— .2	— .22	— .22	— .22
v_s	— 8.8		+ 9.8	—27.47	—20.57	—22.83
Reduction to ⊙	+12.1		— 4.8	+19.73	+12.91	+25.54
Observed *V*	+ 3.3		+ 5.0	— 7.74	— 7.66	+ 2.71

Velocity variable.

First plate very poor, being much underexposed.

π Hydrae R. A. $14^h\ 0^m7$ Dec. — 26° 12′

Magn. 3.5 Type K

Date	1905 Feb. 2.84	1905 Apr. 13.76	1905 May 24.68	1906 Feb. 7.85
Julian day	6879.84	6949.76	6990.68	7249.85
Plate number	578 III	693 IV	727 III	884 III
Photographed by	W.	P.	P.	W.
Measured by	P.	P.	P.	W.
λ				
4233.772	— 5.3			
39.525		+19.5		
41.287	5.3	22.6		
46.968	3.5	20.8	+40.7	— 0.9
50.287	1.9	20.4	41.2	+ 0.3
50.962	6.3	16.5	40.5	+ 2.2
54.505	1.7			
57.815	5.6	17.0		
61.376		22.7		
63.290		22.1	44.8	
65.374				+ 3.6
68.866	2.8	21.2	39.5	
74.935				— 1.0
76.836	3.3			
78.390				— 3.4
82.565	0.8	25.4		
83.169	6.0	19.6		
86.627	2.0	22.7	43.8	
87.605	4.5	24.3	39.2	— 0.3
91.630				0.0
4313.771	3.9	19.6	40.0	+ 1.7
18.867	2.5	19.9	38.4	— 0.9
25.195	4.0	23.4	41.8	— 0.4
25.978	6.6			
28.101	— 3.0	20.2	37.0	— 0.7
30.189	+ 0.2	25.3	43.4	
31.795	— 6.2	16.0		
32.921	2.8			
37.216	3.2	17.8	38.5	— 1.4
38.430	0.2			
38.854		21.3		
40.634	3.8	18.4	37.2	+ 0.4
41.530	5.7	22.6		
43.402		20.9	40.7	
49.150	0.7	21.7	42.0	+ 0.4
55.294	3.2			
59.784	— 2.9	20.4	40.7	+ 0.4
69.924				+ 0.4
73.727	+ 0.6			
75.119	— 4.3	22.6	40.6	+ 1.5
76.107	2.4	18.1	40.0	— 3.4

π Hydrae—(Continued)

Date	1905 Feb. 2.84	1905 Apr. 13.76	1905 May 24.68	1906 Feb. 7.85
4379.396	− 1.9	17.9	37.8	− 3.1
84.873	+ 1.9			
89.413		24.3		
90.118	− 4.4	18.5	39.7	
91.152				− 1.9
95.270				− 1.6
99.907	2.7	20.2	38.6	
4404.927	7.4			
06.810	2.9	20.3	41.1	− 4.3
07.850				− 0.8
25.608		26.3		
27.444				− 1.2
28.711	2.4	19.0	41.4	− 2.0
30.785	2.6		38.2	
35.817	3.3	21.0	41.3	0.0
38.006	9.5			
41.861	5.0	21.4	39.7	+ 4.1
42.510	4.9	21.1	39.6	+ 1.6
43.976		22.8	39.6	
47.915	4.0	18.6	40.2	
66.789	8.8	16.5	44.3	
68.673	4.4	20.7	43.3	
76.211	5.3	19.2	40.5	
81.364		19.9		
89.911	5.1	20.3		
Number of lines	(48)	(45)	(33)	(29)
Mean	− 3.67	+20.68	+40.46	− 0.37
Scale Corr.	.00	+ .05	+ .06	.00
Systematic Corr.	− .22	− .22	− .22	− .22
v_s	− 3.89	+20.51	+40.30	− 0.59
Reduction to ⊙	+29.40	+ 7.20	−12.42	+28.98
Observed V	+25.51	+27.71	+27.88	+28.39

Mean $V = +27.37$ km.

Mean J. D. 2417017.53
Epoch 1905.37

θ Centauri R. A. $14^h\ 0^m8$ Dec. — 35° 53′

Magn. 2.3 Type K

Date	1904 Jan. 31.83	1904 Feb. 29.75	1905 Jan. 30.84	1905 June 12.58
Julian day	6511.83	6540.75	6876.84	7009.58
Plate number	161 III	200 II	571 III	731 III
Photographed by	W.	W.	W.	P.
Measured by	P.	P.	P.	A.
λ				
4199.267	—23.1	—17.9		
4212.801		16.6		
17.720		21.1		
20.509	26.6			
22.382	25.3	23.3		
25.619	31.4			
31.183	26.3			
33.772	25.3	20.7		
38.188		21.8		
38.980				+18.0
41.285		20.6		
43.981			—25.0	
45.435				20.6
46.160				17.7
46.968	26.0	20.7	26.5	
50.287	26.6	22.6	26.4	
50.962	27.2	22.0	27.7	
54.505	28.8	22.7	27.0	
55.134		22.1		
57.815		20.1	28.2	
65.374	24.9	16.9		
74.935			25.6	
78.390			26.4	
82.565			26.7	
83.169			24.9	
86.627		18.5		
87.605	27.2	24.7	27.7	
88.162				19.3
93.239				19.1
94.273			26.4	
4313.771	26.7	20.8	26.5	18.2
18.867	24.8	23.2	26.3	19.5
25.195			26.4	
25.978	27.1			
28.101	26.0	20.3	25.7	22.1
31.795			28.0	
34.101				23.2
37.216	24.5	23.0	26.3	18.5
37.725		23.9		
38.084		23.4		
39.723				20.8

θ Centauri—(Continued)

Date	1904 Jan. 31.83	1904 Feb. 29.75	1905 Jan. 30.84	1905 June 12.58
4340.634		22.3	28.8	
41.530		19.2		
44.625				18.6
47.464		25.5		
49.150		24.0		16.5
52.972			26.9	21.1
55.294			24.5	
59.784		22.9		20.7
69.924			24.2	
71.363			27.2	20.8
75.119			24.1	22.2
76.107		21.2	25.2	20.1
79.396	29.1	24.8	26.7	20.6
88.629		25.4		
89.413	31.1	22.5		
90.118			27.5	
91.152			26.8	19.7
95.270			28.4	
99.907	26.0		27.2	
4401.611				25.3
06.810	30.9	24.1	27.5	23.3
07.850			26.9	20.7
08.571				22.8
17.857			22.7	
18.542			27.6	25.0
27.444				22.4
28.711		23.7		
30.785			25.1	
33.414			26.3	
34.060				18.0
35.214				20.5
35.817	27.9	22.9		17.7
41.861	27.1	23.6	28.2	
42.510	23.3	22.0	26.6	23.7
43.976			28.2	
47.915	27.8	22.4	27.3	21.9
57.656				23.9
59.324				17.5
60.486				24.0
66.789	30.2			21.6
68.673	26.3	21.3	26.0	23.7
76.214		25.5	24.9	
82.376			26.6	
4501.445	26.7			
Number of lines	(28)	(39)	(43)	(36)
Mean	—26.94	—22.06	—26.49	+20.81
Scale Corr.	+ .01	+ .02	+ .08	.00
Systematic Corr.	— .22	— .22	— .22	— .22
v_s	—27.15	—22.26	—26.63	+20.59
Reduction to ⊙	+28.16	+24.64	+28.14	—17.51
Observed V	+ 1.01	+ 2.38	+ 1.51	+ 3.08

Mean V = +2.00 km.

Mean J. D. 2416734.75

Epoch 1904.69

δ Octantis R. A. $14^{h}\ 10^{m}.9$ Dec. — 83° 13′

Magn. 4.1 Type K2M

Date	1905 Feb. 11.82	1905 Feb. 25.81	1905 May 25.72	1905 July 22.54
Julian day	6888.82	6902.81	6991.72	7049.54
Plate number	595 III	614 III	729 III	749 II
Photographed by	W.	W.	W.	W.
Measured by	P.	P.	W.	W.
λ				
4238.980	— 5.8	— 8.0		
46.968	8.1	8.9		
50.287	5.2	7.3		
50.962	5.9	8.8		
65.374		8.6		
78.390	4.8	8.9		
83.169	8.5			
87.605	6.8	9.4		
94.273	8.8			
4313.771	8.7	8.4		
18.867	5.8	8.1		+13.4
25.195	4.2	6.9		
28.101	5.3	7.4	+ 2.1	13.4
31.795	6.5			14.5
37.216	6.8	9.1	+ 3.6	10.4
40.634		10.9		11.5
52.990	7.2		+ 0.5	
59.784		12.1	+ 4.8	15.8
69.924		6.1	+ 6.7	14.1
71.363	7.8			
75.119		9.7		12.7
76.107	4.3	10.7	+ 1.5	17.2
79.396	9.3	13.2	+ 5.6	14.9
90.143	6.2	9.2		
91.152	10.7	9.9	+ 1.5	14.1
95.298	10.8	10.8	— 0.5	14.0
4406.810	9.0	10.1	+ 2.3	14.8
07.850	7.2	8.7	0.0	14.8
11.240		6.1		
18.542	8.5			
27.444			+ 3.6	12.8
28.711				10.8
30.785	9.2	10.0		
33.414	5.0	9.6		
35.817	6.5	7.0	+ 3.6	16.1
41.861	7.3	9.7	+ 3.0	14.9
42.510	5.5	8.1	+ 4.5	13.4
47.915	6.2	10.0		
50.589		11.8		
66.789	6.5	5.4		
68.745	7.7	13.0		
76.214	5.3	10.1		
82.376	7.4	11.3		
Number of lines	(34)	(35)	(15)	(19)
Mean	— 7.02	— 9.24	+ 2.85	+13.87
Scale Corr.	+ .01	+ .02	.00	— .04
Systematic Corr.	— .22	— .22	— .22	— .22
v_s	— 7.23	— 9.44	+ 2.63	+13.61
Reduction to ⊙	+12.68	+13.71	+ 3.28	— 9.14
Observed V	+ 5.45	+ 4.27	+ 5.91	+ 4.47

Mean V = +5.02 km.

Mean J. D. 2416958.22
Epoch 1905.30

η Centauri R. A. 14h 29m2 Dec. — 41° 43′

Magn. 2.6 Type B3A Pec.

Date	1904 Feb. 29.80	1905 Feb. 7.81		1905 Apr. 2.73	1905 Aug. 6.50	
Julian day	6540.80	6884.81		6938.73	7064.50	
Plate number	201 III	584 IV		675 III	762 II	
Photographed by	W.	W.		P.	W.	
Measured by	W.	A.	W.	A.	A.	W.
λ						
4340.634	—19.8	—34.0	—34.8	—15.6	+26.5	+30.3
Systematic Corr.	— .2	— .2		— .2	— .2	
v_s	—20.0	—34.6		—15.8	+28.2	
Reduction to ☉	+25.5	+27.4		+16.3	—26.5	
Observed V	+ 5.5	— 7.2		+ 0.5	+ 1.7	

Velocity variable.

Miss Cannon has found the spectrum of *η Centauri* to be composite and gives an extended discussion of some of its peculiarities in ANN. H.C.O., 28, 180-182. The range of radial velocity, as observed by the expedition, is somewhat extended by more recent observations secured in Chile by Dr. Curtis and Mr. Paddock. These are as follows:

Date	Velocity	Measured by
1907 Mar. 4.862	—11	H.D.C. & Pk.
May 6.572	— 1	H.D.C. & Pk.
July 19.490	—11	H.D.C. & Pk.

Though the observations depend on the measurement of only a single rather hazy line, there is little doubt that they show an actual variation in the velocity.

α^2 *Centauri* R. A. $14^h\ 32^m8$ Dec. — 60° 25′

Magn. 0.3 Type G

Date	1904 Feb. 21.91	1904 Mar. 4.86	1904 June 23.67	1905 Jan. 27.82	1905 Mar. 7.88	1905 Apr. 17.71
Julian day	6532.91	6544.86	6655.67	6873.82	6912.88	6953.71
Plate number	191 III	214 I	356 IV	564 III	621 IV	704 IV
Photographed by	W.	W.	W.	W.	W.	W.
Measured by	W.	W.	W.	W.	W.	W.
λ						
4187.204		—48.3				
88.894		47.7				
89.723		47.6				
96.372		45.1				
99.267		43.8				
4207.291		46.4				
16.351		46.4				
20.509		44.8				
22.382		48.5				
26.904		47.3				
31.183		42.3				
33.772		45.7				
38.188		45.8		—48.7	—46.2	—37.4
46.968	—45.1		—13.3	45.5	45.5	36.0
50.287	47.8	47.2	10.7	48.7	48.0	37.5
50.962	46.0			46.1	47.4	37.1
54.505	48.0	46.1	13.6	47.4	47.4	36.8
55.134		45.7				
57.817					46.9	
60.640		44.1				
61.376	46.5					
65.374			9.6	44.7	42.4	34.0
67.543					46.2	
68.866			10.0			
76.836		44.2				
78.390				50.5	45.9	36.6
82.565	46.1	43.6	13.2	46.5	45.5	36.2
83.169	44.4	46.1	14.9	46.1	46.1	37.2
86.627	42.9	41.4	9.2			
87.605	47.6		15.3	46.8	46.4	36.4
89.525		46.2			46.6	35.2
91.630				46.0	45.4	36.0
4300.211	45.5	44.6			43.5	34.7
00.732					45.4	
13.771	43.6		10.2	45.0	43.9	35.3
18.867	48.9	47.3	15.0	47.5	46.5	37.8
25.195	47.8	46.7	13.4	48.1	46.0	36.9
25.978		46.8	11.9	48.2	46.8	38.7
28.101	46.8			46.6	45.5	38.8
31.795	42.3					
37.216	46.6	45.2	10.8	45.3	46.4	36.1

α^2 *Centauri*—(Continued)

Date	1904 Feb. 21.91	1904 Mar. 4.86	1904 June 23.67	1905 Jan. 27.82	1905 Mar. 7.88	1905 Apr. 17.71
4337.725	47.2	48.4	11.9		45.7	
38.084	47.9		11.2	43.9	43.2	36.8
40.634	45.0	44.6		45.5	43.7	35.8
41.530			14.5		46.7	36.3
49.150	47.7		14.9	48.5	48.1	
55.294			13.5			
59.784	48.7		11.5	47.0	45.5	36.7
67.749	46.4					
69.924	47.6	44.1	11.7	43.9		
76.107	43.8	47.1	12.3	47.1	43.4	34.4
79.396	42.8	45.6	13.2	45.1		36.5
83.720	47.1	46.6	12.0	42.0	45.4	35.9
84.373	44.1					
88.629	50.6		15.0			
89.413	46.3					
91.152				44.2	45.4	34.3
99.907	46.8	48.2	14.2			
4404.927		44.5	12.0	45.4	44.2	34.1
06.810	50.0		11.4	49.0	47.7	37.0
07.850				45.6	46.4	35.7
15.722			12.9			
17.857	45.6	43.0	9.9	42.9		
25.608	45.2		10.0	43.4	44.6	
27.444				47.5	47.1	37.1
28.711	49.0					
30.785	47.1					
32.736	46.1					
35.817	45.0		12.7	45.5	45.5	34.7
41.861	46.0		12.2	46.7	45.9	
42.510	49.8	45.7	13.9	45.2	45.2	36.2
43.976	45.7			45.6	46.4	
47.915	48.2					
61.818	43.5					
68.647	45.6					
Number of lines	(43)	(37)	(34)	(36)	(40)	(33)
Mean	—46.38	—45.75	—12.41	—46.15	—45.75	—36.24
Scale Corr.	+ .12	+ .13	— .04	+ .03	+ .06	.00
Systematic Corr.	— .22	— 22.	— .22	— .22	— .22	— .22
v_s	—46.48	—45.84	—12.67	—46.34	—45.91	—36.46
Reduction to ⊙	+22.09	+21.30	—12.11	+20.93	+21.01	+11.51
Observed V	—24.39	—24.54	—24.78	—25.41	—24.90	—24.95

α[1] Centauri R. A. 14h 32m8 Dec. — 60° 25′

Magn. 1.7 Type K5M

Date	1904 Feb. 25.82	1904 Mar. 4.83	1904 June 23.64	1905 Jan. 27.85	1905 Mar. 7.80	1905 Apr. 17.68
Julian day	6536.82	6544.83	6655.64	6873.85	6912.80	6953.68
Plate number	194 III	213 IV	355 IV	565 IV	620 III	703 III
Photographed by	W.	W.	W.	W.	W.	W.
Measured by	W.	W.	W.	W.	W.	W.
λ						
4187.204		—41.8				
88.894		39.0				
89.723		39.6				
92.728		44.7				
4203.730		43.8				
08.766		40.8				
11.127		41.4				
12.801		37.0				
17.720		40.1				
20.509		39.5				
31.183	—41.5	40.5				
33.772	41.5	43.2	— 7.2			
38.188		40.0			—44.0	
39.525	38.8					
46.968	40.8	39.0	7.5	—39.2	39.5	
50.287		42.1	10.1	41.7	42.0	—32.4
50.962				42.0	42.6	30.5
54.505				40.3	41.0	
55.134		40.1				
57.815		42.0	10.6		41.4	28.6
65.374		36.7				28.2
67.543					42.6	30.6
68.866	38.9					
76.836	37.2					
78.390				38.3	41.2	31.0
82.565	37.7	41.2	2.8	39.8	41.2	30.5
83.169	38.4	38.9	6.2	41.8	40.2	29.5
86.627	38.7	37.4				
87.605				40.7	40.1	30.4
91.630					41.7	29.6
94.936	42.2					
4300.211						28.6
00.732				36.8		32.1
13.771	40.3	37.9	4.8	41.2	41.2	30.5
18.867	41.7	41.9	10.2	40.8	42.8	31.2
25.195				38.6	40.7	31.2
25.978				39.7	43.2	
28.101	42.7	37.2	6.6	41.3	41.7	28.6
31.795	40.0					
37.216	39.6	38.9		42.1	41.8	31.4
37.725	42.5	40.3	8.6		42.5	31.4

α^1 *Centauri*—(Continued)

Date	1904 Feb. 25.82	1904 Mar. 4.83	1904 June 23.64	1905 Jan. 27.85	1905 Mar. 7.80	1905 Apr. 17.68
4338.084	43.6		6.8		40.3	
38.430	38.3					
39.617		40.0				
39.882		38.0				
40.634	40.5	38.9		39.0	40.8	29.0
41.167	41.4	40.0				28.4
41.530	43.4					
43.402			6.5			
47.464	45.7					
49.150				41.3		
55.294	45.9		10.4			31.8
59.784	43.8	40.7	6.7	40.7	41.5	30.8
69.924	40.3	40.5	8.9	40.9	41.7	
76.107	39.5	36.7	6.4	39.3	38.9	30.3
79.396	39.0	41.4	4.6	36.9		30.5
83.720					42.0	
88.629	44.6		11.0			
89.413	42.0					
90.143			9.6			
91.152				36.2	40.4	30.1
99.907		39.6	8.2			
4404.927				40.0	39.6	
06.810	41.4	38.8	9.8	40.1	40.1	31.5
07.850				40.6	40.6	30.4
25.608					39.8	
27.444				41.1	41.9	31.1
28.711			8.2		41.1	31.9
30.785		39.2				
35.817	36.3	37.9	2.6	39.5	40.7	28.6
41.861	39.9		6.5	44.2	40.6	30.4
42.510	40.2	42.0	11.4	39.9	39.9	30.1
47.915	42.4	42.0	7.4			
51.752	41.8					
55.485	44.5					
Number of lines	(36)	(40)	(26)	(29)	(35)	(32)
Mean	—41.03	—40.01	— 7.68	—40.14	—41.18	—30.35
Scale Corr.	+ .03	+ .12	— .02	+ .04	+ .06	.00
Systematic Corr.	— .22	— .22	— .22	— .22	— .22	— .22
v_s	—41.22	—40.11	— 7.92	—40.32	—41.34	—30.57
Reduction to ☉	+22.01	+21.35	—12.08	+20.91	+21.07	+11.54
Observed V	—19.21	—18.76	—20.00	—19.41	—20.27	—19.03

Assuming the difference between the velocities of α^1 and α^2 *Centauri* to be due to relative orbital motion the parallax of the system can be computed by a well-known method.

ΔV represents the observed difference in the velocities of the two components.

A represents the *mean distance* of the components from each other, in kilometers.

Π represents the parallax of the star.

R represents the mean heliocentric distance of the earth, in kilometers.

m_1 and m_2 represent the masses of α^1 and α^2.

a Centauri—(Continued)

Roberts' elements of the orbit of *a Centauri* (*A. N.* No. 3175; also *A. N.* No. 3313) are:

$$
\begin{aligned}
T &= 1875.715 \\
P &= 81.185 \text{ years} \\
e &= 0.52865 \\
\lambda &= 52^\circ\ 0'\ 58'' \\
i &= 79^\circ\ 21'\ 36'' \\
\Omega &= 25^\circ\ 5'\ 50'' \\
a'' &= 17''.71 \\
m_2 : m_1 &= 1.04 \pm .02
\end{aligned}
$$

The formulae for determining the dimensions of the system are as follows:

$$a = \frac{86400 \times 365.26 \times P \sqrt{1 - e^2}}{2\pi \sin i \,[e \cos \lambda + \cos (v + \lambda)]}$$

$$\Pi'' = \frac{a''}{a} R$$

$$m_2 + m_1 = \frac{A^3}{R^3 P^2}$$

A value of the parallax of *a Centauri* based on the first three of the above observations was published in *Lick Observatory Bulletin*, 3, 3, 1904. This value and its related quantities are:

$\Delta V = 5.17$ (1904.24), $\Pi'' = 0.764$, $A = 3.46 \times 10^9$, $m_1 + m_2 = 1.9$. The value of ΔV given here differs slightly from that resulting from a comparison of the same observations as recorded in the table. This discrepancy is insignificant, and is due to the change in the system of reduction referred to in another part of this volume. It may be stated here that the expression for a in the *Lick Observatory Bulletin* to which reference has been made is in error in having e as a coefficient of $\cos (v + \lambda)$. This is merely a misprint and does not enter into the computations on which the values given in the bulletin are based.

The results for the 1905 observations are:

$\Delta V = 5.52$ km., $\Pi'' = 0.694$, $a = 3.81 \times 10^9$, $m_1 + m_2 = 2.5$.

Taking the mean of these values we have

$$
\begin{aligned}
\Pi'' &= 0.73 \\
a &= 3.64 \times 10^9 \text{ km.} \\
m_1 + m_2 &= 2.2
\end{aligned}
$$

Assuming Roberts' value of $\frac{m_1}{m_2}$ we have

$$\left.\begin{aligned} m_1 &= 1.08 \\ m_2 &= 1.12 \end{aligned}\right\} \text{ in terms of the Sun's mass.}$$

It should be remembered that while the uncertainty in the determination of m_1 and m_2 is very great, the ratio of the two masses is quite accurately known.

The radial velocity of the centre of mass of the system of *a Centauri*, assuming $m_2 : m_1 = 1.04$, is -22.19 km. per sec. for the epoch 1904.70.

α Circini R. A. $14^h\ 34^m4$ Dec. — 64° 32′

Magn. 3.4 Type F

Date	1904 Feb. 4.86	1904 Mar. 7.80	1905 Feb. 5.86	1905 Apr. 15.70
Julian day	6515.86	6547.80	6882.86	6951.70
Plate number	167 IV	222 I	582 III	695 III
Photographed by	W.	W.	P.	P.
Measured by	A.	P.	A.	P.
λ				
4238.980		— 7.5	—13.2	— 4.2
39.965			17.5	
45.435	—10.0			
47.584	16.3		16.3	
50.287	9.0	9.3	11.8	5.4
50.962	11.7	14.9	13.2	5.4
54.505	14.4	9.8	11.8	4.0
58.370			13.7	
71.325	13.3			
71.934	12.9		11.3	
74.935	9.4	6.0	10.3	2.7
82.565	9.6	9.2	13.3	3.2
83.169			11.8	4.5
94.273	11.5	13.1	10.3	2.7
4300.211	11.6			2.2
13.034		18.1	10.9	1.6
18.867		2.5	13.4	9.4
25.195		13.3		
25.939		15.3	15.7	4.3
40.634	10.9		9.1	
52.012	8.3		10.0	
75.119	11.7	14.3	13.1	6.1
83.720	11.3	11.5	10.6	4.3
95.242		12.5	12.8	— 6.4
99.907				+ 0.4
4404.927	7.9	13.3	12.5	— 1.4
16.985			11.2	
17.857	13.7		15.2	3.2
25.608		15.0		
35.178	16.1			
35.817	11.0	16.8	13.3	6.5
42.510		6.9		
43.976		15.8	12.4	5.3
50.589		12.8		0.2
59.324			7.3	
68.623	13.7	13.7	13.5	4.2
76.211		9.5		1.5
81.364	14.2	11.1	9.7	— 3.0
Number of lines	(21)	(23)	(28)	(24)
Mean	—11.83	—11.83	—12.33	— 3.80
Scale Corr.	+ .01	+ .01	+ .01	.00
Systematic Corr.	— .22	— .22	— .22	— .22
v_s	—12.04	—12.04	—12.54	— 4.02
Reduction to ⊙	+19.68	+19.80	+19.88	+12.24
Observed V	+ 7.64	+ 7.76	+ 7.34	+ 8.22

Mean $V = +7.74$ km. Mean J. D. 2416724.56

Epoch 1904.68

α Lupi R. A. 14ʰ 35ᵐ3 Dec. — 46° 58′

Magn. 2.9 Type B2A

Date	1904 July 21.56	1905 Jan. 26.87	1905 Apr. 8.69	1905 July 23.52
Julian day	6683.56	6872.87	6944.69	7050.52
Plate number	362 II	562 II	689 III	752 II
Photographed by	W.	W.	W.	W.
Measured by	W.	A.	P.	A.
λ				
4253.821			—12.8	
67.280	+29.8	—19.0	6.0	+23.5
85.089		19.0	5.1	
4317.302		20.0	6.3	21.5
19.774		15.6	5.8	27.8
40.634	34.3	17.7	5.6	19.5
45.725		18.1	16.3	24.0
47.555			10.9	
49.560		15.4	3.7	24.0
51.426		19.5	7.7	25.4
67.023		14.9	5.3	28.2
88.100	34.6	13.1	8.7	26.4
96.022			12.9	
4415.035		16.7	4.6	23.2
17.129		20.6	5.0	18.7
37.718	30.3		7.2	27.9
47.188		15.5	1.7	22.0
71.693	28.7	19.8	5.7	22.8
81.375	31.7	19.0	7.7	24.3
Number of lines	(6)	(15)	(19)	(15)
Mean	+31.57	—17.59	— 7.32	+23.95
Scale Corr.	+ .29	+ .03	.00	— .08
Systematic Corr.	— .22	— .22	— .22	— .22
v_s	+31.64	—17.78	— 7.54	+23.65
Reduction to ⊙	—23.48	+25.32	+14.66	—23.69
Observed *V*	+ 8.16	+ 7.54	+ 7.12	— 0.04

Velocity variable. Mean J. D. 2416887.91

Epoch 1905.11

The variation in velocity indicated by the fourth observation is confirmed by the following series kindly secured by Messrs. Curtis, Paddock, and Moore:

Date	Velocity	Measured by
1907, Mar. 4.891	+ 7	Pk.
23.836	+ 8	H.D.C.
25.833	+ 7	H.D.C.
June 3.530	+ 7	Pk.
July 27.542	+ 9	Pk.
1909, July 5.619	+17	Pk.

α Apodis R. A. 14h 35m.4 Dec. — 78° 37′

Magn. 3.8 Type K5M

Date	1904 Mar. 16.77	1905 Feb. 18.82	1905 Mar. 14.77	1905 July 16.60	
Julian day	6556.77	6895.82	6919.77	7043.60	
Plate number	250 III	600 III	636 III	740 II	
Photographed by	W.	W.	P.	W.	
Measured by	P.	P.	P.	W.	A.
λ					
4238.980					+12.5
39.965					9.9
45.435					10.9
46.160					9.3
46.968		—15.4	—15.8	+ 9.8	10.1
47.584					12.3
50.287		14.9	14.2	10.5	10.3
50.962		14.9	11.5	10.2	
58.50					10.6
65.374		16.0			
68.866					9.8
71.325					10.5
74.935				10.8	
76.836		13.7	16.8		
78.390			17.3	11.2	
82.565				12.6	
83.169				12.3	
87.605		15.2	15.9	9.7	9.7
88.162					10.7
93.272					9.8
94.273					9.1
4300.723		15.0			
13.771		16.4	17.7		
14.357					8.8
18.867	—12.1		13.2		
25.195				13.0	
25.978				8.8	
28.101	13.9		14.4	10.2	9.7
31.795	16.5	17.5	14.9		
34.101					12.2
37.216	14.5	15.3	17.4	8.9	11.4
38.084		18.1			
39.723					9.4
40.634			18.4		
43.402					9.4
44.625					10.8
47.464					9.9
49.150				10.1	
52.012					11.1
52.990	14.8		14.6		8.7
55.294			14.1		8.8

a Apodis—(Continued)

Date	1904 Mar. 16.77	1905 Feb. 18.82	1905 Mar. 14.77	1905 July 16.60	
4359.784		10.8		11.7	11.9
69.924	16.6			10.0	
71.363	13.6		15.3		10.1
75.119		20.0		12.7	12.7
76.107	13.5	13.1	15.7		9.2
79.396	13.4	16.4	16.0	9.7	10.2
83.720				12.5	
90.143			15.4		
91.152	18.4		15.1	10.3	9.6
95.298			17.3		
4401.611					10.0
04.927				12.0	
06.810	12.5		15.6	11.7	8.0
07.850	13.5		15.2	12.5	13.2
11.240	10.3				
16.783			12.2		
18.542			16.5		
27.444					10.8
30.785		21.1		9.2	
33.414		13.7	13.3		
34.060					12.1
35.817		14.5		8.5	
41.861	13.2	14.7	15.2	11.0	13.8
42.510	10.1	14.0	14.8	10.2	11.4
43.976		13.6			
47.915	15.0	14.5	13.7	9.8	10.1
57.656					12.2
66.789	13.6	13.4	12.9	10.9	
68.745	17.2	17.2	15.5	8.3	8.5
71.646		9.9			
76.214	10.2	15.8	15.6	9.3	
82.376	17.1		15.9	9.4	
Number of lines	(20)	(26)	(32)	(31)	(41)
Mean	—14.00	—15.20	—15.23	+10.58	+10.47
Scale Corr.	— .01	+ .02	+ .01	— .02	— .01
Systematic Corr.	— .22	— .22	— .22	— .22	
v_s	—14.23	—15.40	—15.44	+10.34	
Reduction to ⊙	+15.41	+15.43	+15.54	—10.16	
Observed V	+ 1.18	— 0.03	+ 0.10	+ 0.18	

Mean V = +0.36 km.

Mean J. D. 2416853.99
Epoch 1905.02

c^1 *Centauri* R. A. $14^h\ 37^m5$ Dec. — 34° 44′

Magn. 4.1 Type K

Date	1904 Mar. 15.78	1904 Apr. 16.80	1905 Feb. 24.82	1905 June 14.68	1906 Feb. 19.80
Julian day	6555.78	6587.80	6901.82	7011.68	7261.80
Plate number	247 II	294 III	612 III	735 III	889 II
Photographed by	W.	W.	W.	P.	W.
Measured by	P.	P.	P.	W.	W.
λ					
4238.980			—65.8		
43.981			66.4		
46.968	—62.6		67.0		—64.1
48.384	56.3				
50.287			67.6		
50.962			64.7		
65.374	60.9				
68.866	57.9				
74.935			68.0		
76.836			66.5		
78.390			68.8		68.6
82.565			62.7		
83.169			69.6		
87.605			67.5		67.8
94.273			69.1		
4318.867		—51.5	65.3		66.3
28.101	62.0	50.8	66.4	—23.7	63.5
31.795			69.9	18.1	67.3
37.216			65.1	21.8	
40.634			68.9		
47.464					71.3
49.150	62.4				64.1
52.972		51.3	67.1	22.7	
55.294			65.3		
59.784	61.5	46.7		22.7	64.6
69.924	63.5		67.1	23.8	65.1
71.363			66.2		
75.119			67.5		
76.107	64.0	47.7	64.7	20.6	62.1
79.396	64.7		69.8	27.4	66.5
89.413	59.5				
90.118			67.8		
91.152			65.5	21.4	63.6
95.270			64.3	20.1	
99.907			69.1		
4406.810	64.3	48.4	68.2	·	68.5
07.850			66.9	26.5	67.1
18.542					64.8
27.444				22.3	67.0
28.711	62.9	46.4		20.3	69.4
30.785		50.0			

e^1 *Centauri*—(Continued)

Date	1904 Mar. 15.78	1904 Apr. 16.80	1905 Feb. 24.82	1905 June 14.68	1906 Feb. 19.80
4433.817			63.8		
41.861			70.6		
42.310	61.7	52.7	63.9	19.1	67.1
43.976	59.3				
47.913	60.8	52.5	65.8		
59.324				23.3	
66.789	59.8	45.3	63.7	24.2	
68.673	57.5	50.9	62.8		
76.211			69.0		
82.376			67.0		
89.911	54.5				
4501.443	61.0				
Number of lines	(20)	(12)	(38)	(16)	(19)
Mean	—60.86	—49.52	—66.72	—22.38	—66.25
Scale Corr.	+ .05	— .01	+ .15	+ .08	+ .09
Systematic Corr.	— .22	— .22	— .22	— .22	— .22
v_s	—61.03	—49.75	—66.79	—22.52	—66.38
Reduction to ☉	+22.96	+10.46	+27.36	—16.15	+28.11
Observed V	—38.07	—39.29	—39.43	—38.67	—38.27

Mean V = 38.73 km.

Mean J. D. 2416863.78

Epoch 1905.05

β Lupi R. A. $14^h\ 52^m0$ Dec. — 42° 44′

Magn. 2.8 Type B2A Pec.

Date	1904 May 31.60			1905 Jan. 29.87	1905 Feb. 7.86	1905 Aug. 11.50	
Julian day	6632.60			6875.87	6884.86	7069.50	
Plate number	335 II			569 III	585 IV	768 II	
Photographed by	P.			W.	W.	W.	
Measured by	W.	W.	A.	W.	W.	W.	A.
λ							
4340.634	+17	+16	+ 4.0	—31	—35	+19	+22.5
88.100	+11	+ 3	+ 5.8	—30	—28	+28	+27.0
4471.693	—18	—24	—16.4	—36	—25	+22	+30.4
Number of lines	(3)	(3)	(3)	(3)	(3)	(3)	(3)
Mean	+3.3	—1.7	—2.2	—32.3	—29.3	+23.0	+26.6
Scale Corr.	.0	.0	.0	.0	.0	.0	.0
Systematic Corr.		— .2		— .2	— .2	— .2	
v_s		— .4		—32.5	—29.5	+24.6	
Reduction to ⊙		—7.27		+26.68	+27.33	—26.67	
Observed *V*		—7.7		— 5.8	— 2.2	—2.1	

Velocity variable (H.C.O.). Mean J. D. 2416865.71

Epoch 1905.05

This star has been announced by the Harvard College Observatory to be a spectroscopic binary, the lines having been observed, on one occasion, to be double, *Ann. H.C.O.*, 28, 177. None of the plates secured by the Mills expedition show the double lines, though the tabulated observations, taken in connection with the two given below which were secured later by Dr. Curtis seem to indicate that some change takes place in the spectrum. The observations given above indicate a relative shift of the lines, which may possibly be due to the overlapping of the two spectra reported by Mrs. Fleming.

Date	Velocity	Measured by
1907, July 31.49	+ 7 km.	H.D.C.
Aug. 3.48	+ 3 km.	H.D.C.

κ Centauri R. A. 14ʰ 52ᵐ7 Dec. — 41° 42′

Magn. 3.4 Type B3A

Date	1904 Apr. 5.50		1905 Feb. 10.85	1905 Apr. 24.69		1905 July 18.54
Julian day	6576.50		6887.85	6960.69		7045.54
Plate number	277 II		593 IV	712 III		745 III
Photographed by	P.		W.	W.		P.
Measured by	P.	A.	P.	A.	P.	A.
λ						
4267.280	— 6.8	—11.4	—18.4	— 4.9	— 4.0	+33.6
4340.634	16.5		18.4	4.8	2.9	28.5
88.100	6.5		17.7	7.0	5.7	32.3
4437.718	15.4	9.8	9.7 wt. ½	5.0	7.3	42.0 wt. ½
69.832				4.4		
71.693	16.0	12.6	20.4	3.7	2.0	37.3
81.375	12.4	13.4	16.0	3.3	3.7	37.9 wt. ½
Number of lines	(6)	(4)	(6)	(7)	(6)	(6)
Mean	—12.27	—11.80	—17.40	— 4.73	— 4.27	+34.34
Scale Corr.	— .01	— .01	+ .03	+ .01	+ .01	— .03
Systematic Corr.	— .22		— .22	— .22		— .22
v_s	—12.26		—17.59	— 4.71		+34.09
Reduction to ⊙	+16.89		+27.63	+ 9.33		—23.79
Observed *V*	+ 4.63		+10.04	+ 4.62		+10.30

Velocity variable.

Mean J. D. 2416867.64

Epoch 1905.06

The variable velocity of this star was detected by Dr. Curtis and Mr. Paddock from a comparison of their later observations with those given above. Their observations are as follows:

Date	Velocity	Measured by
1907, May 5.71	+ 13.3	H.D.C.
07, May 21.56	+ 13.2	Pk.
07, June 3.58	+ 15.9	Pk.
07, June 22.55	+ 17.1	Pk.
08, Jan. 22.87	+ 10	H.D.C.
08, Jan. 26.84	+ 6	H.D.C.

ζ Lupi R. A. $15^h 5^m1$ Dec. — 51° 43′

Magn. 3.5 Type K

Date	1904 Feb. 12.86	1904 Apr. 7.71	1905 Apr. 3.88	1906 Feb. 21.85
Julian day	6523.86	6578.71	6939.88	7263.85
Plate number	185 III	283 II	679 IV	891 IV
Photographed by	P.	P.	W.	W.
Measured by	P.	P.	P.	W.
λ				
4238.980	—29.7		—27.6	
43.981			29.4	
46.968	34.7	—26.6	28.2	—35.7
50.287	32.8	26.7	29.9	35.3
50.962	36.0	28.5	28.2	36.6
54.505		31.4	26.9	36.8
57.815		29.4		
63.290		25.7		
68.866		29.6		
74.935	35.0		26.7	38.8
78.390	36.5		27.7	
82.127		26.3		
82.565		24.1	25.9	
83.169	38.9	25.9		
86.627		27.8		
87.605		30.5		
91.630			24.0	
4313.771		27.9		32.5
18.867	32.8	25.2		34.3
25.195	37.7		27.6	35.8
25.978		23.0	27.7	34.8
28.101	34.7	25.3	28.2	36.7
31.795		27.2	29.2	31.9
37.216	29.0	28.1	28.7	36.1
37.725		27.4		
40.634	35.7	26.3	26.7	35.8
41.530			24.7	
43.402		25.5		
52.972	32.3			
59.784		27.0	29.6	35.6
69.924	37.8			36.1
71.363	35.0			
75.119			25.2	
76.107	35.0	20.9	26.6	32.2
79.396	34.6	28.7		37.4
83.720			27.4	
88.629			31.3	
90.118	39.2	26.1		
91.152			27.9	35.8
95.270	33.2		26.2	37.4
99.907	39.2	25.7	27.8	

ζ Lupi—(Continued)

Date	1904 Feb. 12.86	1904 Apr. 7.71	1905 Apr. 3.88	1906 Feb. 21.85
4404.927			27.0	37.6
06.810	39.0	27.5	26.3	38.1
07.850	32.0		29.6	38.2
11.240			26.2	
15.312	33.3			
17.857		23.1	25.8	
18.542			27.4	
27.444				35.1
28.711		27.2		
30.785			27.7	
33.414	33.7	24.0	27.9	
35.817	33.7	24.6	28.6	
41.861	35.3	27.4	29.6	
42.510	30.0	28.7	28.0	32.6
43.976		26.7		
47.915	33.4	24.6	26.0	
66.789	34.8	22.8	32.6	
68.673	36.9	21.2	29.4	
76.214	38.2	28.8	27.0	
82.376	36.1		28.5	
Number of lines	(32)	(38)	(41)	(24)
Mean	—34.88	—26.45	—27.73	—35.72
Scale Corr.	+ .06	— .01	+ .03	+ .10
Systematic Corr.	— .22	— .22	— .22	— .22
v_s	—35.04	—26.68	—27.92	—35.84
Reduction to ⊙	+25.26	+16.97	+18.01	+25.37
Observed V	— 9.78	— 9.71	— 9.91	—10.47

Mean V = —9.97 km.

Mean J. D. 2416826.58
Epoch 1904.94

ϕ^1 Lupi R. A. $15^h 15^m5$ Dec. — 35° 54′

Magn. 3.6 Type K5M

Date	1904 Apr. 17.71	1905 Mar. 8.82	1905 Apr. 28.79	1905 Aug. 5.58
Julian day	6588.71	6913.82	6964.79	7063.58
Plate number	297 III	623 III	722 IV	759 III
Photographed by	W.	W.	W.	W.
Measured by	A.	P.	P.	A.
λ				
4238.980		—58.4		— 2.5
39.965	—44.9			— 2.3
45.435				— 0.6
46.160				— 2.8
46.968		59.0	—39.2	— 3.3
47.584				— 0.3
50.287		55.3	42.7	
50.962		57.3	37.2	
65.374		59.1		
68.866			38.7	— 1.8
78.390		57.8		
83.169		54.3		— 4.6
87.605		58.5	37.3	
91.630		62.3		
94.273				— 4.2
4300.732		59.2		
14.357				— 1.0
18.867		54.7	39.6	— 1.9
25.195			38.5	
28.101	39.6	57.2	38.5	— 4.7
30.189			38.2	
31.795			41.6	— 5.1
32.921	44.3			
34.101	43.4			— 1.8
35.000	42.1			— 0.5
37.216		56.6	38.8	+ 0.8
39.723	43.2			— 0.7
40.634		59.8	44.0	
44.625	42.1			— 2.3
46.725			39.1	
47.464			37.0	
49.150			38.7	
51.973	44.8			
52.010				— 4.2
52.990	44.0			— 1.7
55.294		57.6		— 1.6
59.784	40.6		36.6	+ 1.8
69.924	42.6	56.1		— 1.1
71.363	42.5			— 1.9
75.119		57.4	42.1	— 1.9
76.107	42.0	56.5	38.1	— 3.0

φ Lupi—(Continued)

Date	1904 Apr. 17.71	1905 Mar. 8.82	1905 Apr. 28.79	1905 Aug. 5.58
4379.396		58.7	42.5	— 2.4
89.413			37.8	
90.143	43.1		40.7	— 4.4
91.152		58.6		— 1.8
95.298	44.6	57.4		— 3.9
4400.675	41.9			— 2.0
01.611				— 1.5
06.810		56.0	43.1	— 1.7
07.850		58.7		— 1.4
11.240		56.6		
16.752				— 2.9
18.542		56.2		
27.444	41.2			— 2.0
28.711			42.0	
30.785			44.0	
33.414		59.1		
34.060				— 3.4
35.244				— 4.4
35.817			39.3	— 4.2
41.861		59.0	39.1	— 4.5
42.510	41.2	58.1	41.4	— 3.1
43.976			41.4	
47.915	43.7	58.4	36.5	— 4.9
50.589		55.9		
51.752			40.6	
57.656				— 3.5
59.324	42.0			— 1.7
66.789	42.9	56.4	38.9	— 2.1
68.745		57.8	39.5	— 2.6
76.214		59.7	43.5	
82.376		60.7		
89.911			42.4	
Number of lines	(21)	(34)	(34)	(46)
Mean	—42.70	—57.78	—39.96	— 2.43
Scale Corr.	— .02	+ .10	+ .04	+ .01
Systematic Corr.	— .22	— .22	— .22	— .22
v_s	—42.94	—57.90	—40.14	— 2.64
Reduction to ☉	+13.97	+26.84	+ 8.95	—27.57
Observed V	—28.97	—31.06	—31.19	—30.21

Mean V = —30.36 km.

Mean J. D. 2416882.72
Epoch 1905.10

υ Librae R. A. $15^h\ 30^m.9$ Dec. — 27° 48′

Magn. 3.8 Type K2M

Date	1904 May 14.77
Julian day	6615.77
Plate number	319 II
Photographed by	W.
Measured by	P.
Number of lines	(15)
Mean	—28.59
Scale Corr.	— .05
Systematic Corr.	— .22
v_s	—28.86
Reduction to ☉	+ 1.96
Observed V	—26.90

Mean V = — 26.90 km. Mean J. D. 2416615.77

Epoch 1904.37

In the few cases where only one observation of a star was secured the velocities corresponding to the individual lines are not given. This star has also been observed at Mt. Hamilton with the Mills spectrograph, with results as follows:

Date	Velocity
1905.15	—25.5 km.
1905.24	—23.6 km.
1908.54	—24.2 km.
Mean	—24.4 km.

δ Trianguli Australis R. A. $16^h\ 6^m.4$ Dec. — 63° 26′

Magn. 4.0 Type G.

Date	1904 May 8.80	1904 June 7.60	1905 Mar. 30.78	1905 Aug. 7.59
Julian day	6609.80	6639.60	6935.78	7065.59
Plate number	314 IV	345 II	669 III	763 II
Photographed by	P.	W.	W.	P.
Measured by	W.	W.	P.	Pk.
λ				
4246.968			—24.9	
50.287			25.4	
50.962			25.4	
54.505			25.3	
65.374			20.4	
82.565			21.9	
87.605			26.2	
4313.034	—13.1		26.0	
18.867		— 5.2	23.6	
25.195	18.0	— 3.7	27.3	
25.978	17.1		25.2	
28.101		+ 0.2	24.1	
31.795		+ 1.4	23.1	
32.921			21.2	
37.216		— 4 7	21.5	
39.617			21.1	
46.725			23.9	
49.150			27.3	
52.949	12.4	— 4.8		
59.784		— 1.4		
69.924	13.2			
75.119			24.5	
76.107	16.2	— 4.4	25.1	
79.396			25.0	
83.720			24.0	
88.629			24.8	
89.413			24.8	
90.118			25.4	
91.152		— 8.4		
99.907			21.5	
4404.927	14.8	— 3.6	24.4	
06.810		— 4.1	25.4	
17.857			25.2	
27.444	16.2	— 4.7		
28.711			28.0	
30.785			24.0	
35.817			28.3	
41.861			25.3	
42.510		— 4.3	22.1	
43.976			24.3	
47.915	17.2	— 7.5	23.2	

δ *Trianguli Australis*—(Continued)

Date	1904 May 8.80	1904 June 7.60	1905 Mar. 30.78	1905 Aug. 7.59
4459.324	16.2	— 3.8		
66.789		— 3.8	26.4	
68.647		— 1.2	24.3	
69.545		— 3 8		
76.214	16.6	— 6.1	23.6	
85.846		— 4.5		
Number of lines	(11)	(20)	(39)	
Mean	—15.54	— 3.92	—24.45	
Scale Corr.	.00	— .01	— .03	
Systematic Corr.	— .22	— .22	— .22	
v_s	—15.76	— 4.15	—24.70	
Reduction to ⊙	+ 9.63	— 1.05	+20.18	
Observed V	— 6.13	— 5.20	— 4.52	— 4.69

Mean V = —5.13 km.

Mean J. D. 2416812.69
Epoch 1904.91

γ Apodis R. A. $16^h\ 18^m1$ Dec. — 78° 40′

Magn. 3.9 Type K

Date	1904 Apr. 22.72	1905 Mar. 17.79	1905 Apr. 5.77	1905 July 21.66	
Julian day	6593.72	6922.79	6941.77	7048.66	
Plate number	307 III	645 III	684 III	747 II	
Photographed by	P.	P.	W.	W.	
Measured by	P.	P.	P.	W.	A.
λ					
4239.525			—11.9		
39.965					+17.2
41.287		— 8.6	8.9		
45.435					17.3
46.160					16.0
46.968	—10.4	10.6	7.9	+18.6	17.8
47.584					17.1
50.287	15.0	15.2	8.5	16.2	15.4
50.962	14.1	10.0	8.5	14.9	14.3
54 505		11.1	10.7	14.4	13.7
65.374		9.7			
68.866		7.8	7.5		15.3
71.325					13.7
74.935				16.0	14.4
82.565		8.0	6.8		
83.169	10.5	13.3	9.6	13.9	
87.605		10.4	11.6		
92.304					15.1
94.273					13.3
4300.211		10.0		12.9	
13.034				16.3	
13.771		15.0	8.4		
14.357					15.2
18.867		11.6	10.5		15.1
25.195		9.7	9.8	17.6	19.1
25.978		13.4	9.0	13.4	14.4
28.101		10.2	9.7	15.5	15.3
31.795	5.6	11.8	10.2		
37.216		8.2	9.1	14.3	15.7
38.430		8.1			
39.723					16.1
40.634	7.5	9.8	5.7	15.0	15.7
41.530		9.7			
43.402		12.0	8.5		
44.625					14.0
49.150	10.5	11.4			
52.012					14.5
52.972					14.1
55.294		11.1	8.2		
59.784		10.1	9.4	14.7	14.5
75.119		14.9	8.8	12.0	12.2

γ *Apodis*—(Continued)

Date	1904 Apr. 22.72	1905 Mar. 17.79	1905 Apr. 5.77	1905 July 21.66	
4376.107	11.8	11.2	9.0	17.2	15.5
79.396	14.1	16.2	7.7	11.9	11.9
83.720	6.9	14.6	9.4	14.4	15.5
88.629		7.9			
89.413			7.6		
90.118	7.4	9.7	8.6	12.6	16.7
95.270				15.2	16.2
99.907		10.1	10.3		
4401.611					15.0
04.927	6.6	7.4	6.2	14.4	15.2
06.810	8.4	10.5	9.8		14.2
07.850				14.8	14.4
08.571					14.5
15.312					13.9
17.857			5.7		
27.444					14.0
28.711	13.4	12.2	10.0		
30.785	10.8	13.0	9.2		
35.214					15.7
35.817		10.8	7.7		
41.861	10.4	11.7	11.3		
42.510	6.9	12.8	10.6		18.5
43.976	7.5	10.8	10.0		
47.915	8.8	11.0	6.7	16.8	17.0
57.656					18.6
59.324					17.0
60.486					17.1
66.789	9.1	14.6	12.4		
68.673	13.0	10.2	11.0		16.5
76.214	13.0	11.8	8.0		
90.253	17.4				
Number of lines	(23)	(44)	(41)	(23)	(45)
Mean	—10.40	—11.10	— 9.03	+14.91	+15.42
Scale Corr.	.00	— .01	— .01	— .02	— .02
Systematic Corr.	— .22	— .22	— .22	— .22	
v_s	—10.62	—11.33	— 9.26	+14.92	
Reduction to ☉	+12.66	+16.69	+15.29	—10.03	
Observed V	+ 2.04	+ 5.36	+ 6.03	+ 4.89	

Velocity variable.

The variability indicated by the above observations is fully confirmed by later ones secured by Messrs. Curtis, Moore, and Paddock at Santiago as follows:

Date	Velocity	Measured by
1907, June 27	+ 8.2	Olivier
09, Aug. 7	+ 6	Paddock
09, Aug. 19	+ 2.3	Mrs. Moore

α Scorpii R. A. 16ʰ 23ᵐ3 Dec. — 26° 13′

Magn. 1.2 Type Ma Comp.

Date	1904 June 24.62	1905 Mar. 22.81	1905 Mar. 28.81	1905 Mar. 29.82	1906 Feb. 24.83
Julian day	6656.62	6927.81	6933.81	6934.82	7266.83
Plate number	357 II	654 III	663 III	666 IV	896 III
Photographed by	W.	W.	W.	W.	H.D.C.
Measured by	P.	A.	W.	W.	A.
λ					
4245.435		—29.0			—31.6
46.160		29.6			
46.968		30.2			
50.287		28.4			
50.962		27.8			
58.500		29.5			28.7
65.320		29.0			33.4
71.325		28.6			
82.565					31.4
83.169					32.5
94.273		25.7			32.4
4318.867		27.0		—25.7	29.8
23.386				18.2	
25.195		29.0	—26.1		
25.978		29.5		26.1	
28.101	+11.8		24.3	26.2	29.6
30.189	13.4		24.8	21.4	27.4
31.795	9.8			24.0	31.7
32.921		27.5			31.1
34.101		28.2			30.9
35.000		28.8			29.2
37.216			27.6	26.2	
39.723		30.8			
44.625		25.6			29.4
47.464		29.8			32.1
47.705	14.4				
49.150	6.9				
51.973		26.7			
53.008		28.3			29.9
55.294	9.5				
59.784	15.7	25.6	22.0	24.5	28.3
69.924	11.2	25.3	28.0		30.1
71.363		26.9			31.3
76.107	12.1	27.0	27.9	25.6	30.4
79.396	7.2	28.1	26.7	25.8	31.7
83.720		28.6	27.6	23.6	27.8
89.413	8.8	28.8	27.7	23.9	31.1
90.168		26.2	27.3	24.8	31.2
95.298		27.8			32.3
4400.625		25.7			28.4
01.611		26.7			

a Scorpii—(Continued)

Date	1904 June 24.62	1905 Mar. 22.81	1905 Mar. 28.81	1905 Mar. 29.82	1906 Feb. 24.83
4404.927		22.4			
06.810	5.5	29.6	27.7	25.0	31.9
07.850		32.4			
08.571		28.3			
15.312		26.0			
16.752		29.1			
27.444		27.4			30.2
28.711	5.0		33.2	30.8	
30.785	9.3				
35.244		25.6			
41.861			30.8	27.1	
42.510	3.9	28.6	24.8	25.6	28.0
47.915	6.7				29.5
55.485				29.0	
57.656		33.5			32.1
59.301					28.2
66.789	9.0	28.2	28.7	26.1	29.1
68.745		28.7		30.1	32.9
76.214	8.1		31.0	25.3	
85.846	11.2				
89.911			26.1		
Number of lines	(19)	(43)	(19)	(21)	(34)
Mean	+ 9.49	—28.03	—27.35	—25.48	—30.46
Scale Corr.	+ .02	+ .04	— .03	— .01	+ .06
Systematic Corr.	— .22	— .22	— .22	— .22	— .22
v_s	+ 9.29	—28.21	—27.60	—25.71	—30.62
Reduction to ⊙	—12.10	+27.62	+26.21	+25.94	+30.15
Observed V	— 2.81	— 0.59	— 1.39	+ 0.23	— 0.47

Velocity variable.

The spectroscopic orbit of this star has not yet been determined. It appears, however, to have a period of about 5½ years. The velocity of the system is probably about —2½ km.

τ Scorpii R. A. $16^h\ 29^m7$ Dec. — 28° 1′

Magn. 2.9 Type B

Date	1904 June 1.74	1904 July 1.55	1905 Mar. 23.91	1905 Aug. 20.52
Julian day	6633.74	6663.55	6928.91	7078.52
Plate number	341 III	360 II	658 IV	772 II
Photographed by	P.	W.	W.	P.
Measured by	A.	A.	P.	A.
λ				
4253.660	+ 5.9	+14.5		+30.8
54.153	— 2.0	14.8		33.5
67.280	+ 2.4	17.8	—29.1	26.4
75.589	+ 2.2	18.8		29.3
85.089	+ 3.0	13.9		30.7
4303.951		21.4	25.6	26.8
17.302	+ 1.8	19.3	27.9	27.9
19.774	+ 0.9	14.2	25.1	28.9
40.634	+ 1.4	19.5	24.7	
45.725	+ 0.1	11.8	22.9	27.2
47.555		14.5	27.0	29.2
49.560	+ 1.8	15.6	24.3	29.0
51.426	+ 4.5	18.6	22.2	28.8
67.023	— 0.4	13.0	23.1	28.4
88.100	+ 3.8	18.0	21.8	32.9
96.022				33.6
4415.035	+ 4.1	17.0	24.6	28.6
17.129	+ 1.1	13.3	26.0	27.6
37.718	0.0		31.3	34.7
65.589	— 0.2			
66.503	+ 6.1			
71.693	— 0.4	14.7	24.9	29.3
81.375	+ 8.1	15.0	30.9	26.0
Number of lines	(20)	(19)	(16)	(20)
Mean	+ 2.21	+16.09	—25.71	+29.48
Scale Corr.	+ .01	+ .07	+ .05	— .02
Systematic Corr.	— .22	— .22	— .22	— .22
v_s	+ 2.00	+15.94	—25.88	+29.24
Reduction to ☉	— 0.36	—14.22	+27.46	—28.72
Observed *V*	+ 1.64	+ 1.72	+ 1.58	+ 0.52

Mean *V* = +1.37 km. Mean J. D. 2416826.18

Epoch 1904.94

II *Scorpii* R. A. 16^h 29^{m}8 Dec. — 35° 3′

Magn. 4.3 Type Ma

Date	1905 Mar. 10.85	1905 Mar. 23.80	1905 Aug. 4.61
Julian day	6915.85	6928.80	7062.61
Plate number	626 IV	657 III	757 II
Photographed by	W.	W.	W.
Measured by	W.	W.	W.
λ			
4318.867	—28.0	—25.6	+23.1
28.101	28.6		25.4
31.795	32.2	28.0	19.1
37.216	31.4	29.3	
49.150	31.9	33.3	
53.008	29.6	28.1	22.1
59.784	26.4	26.4	24.6
69.924	30.5	26.8	23.1
75.119	29.5	27.7	
76.107	28.4	28.4	21.7
79.396	32.1	30.9	23.3
91.152		29.7	21.7
95.298	31.6	27.4	22.8
4406.810	29.6	28.0	26.5
07.850	31.6	30.8	24.6
27.444	29.1	27.1	24.3
28.711	32.3	29.5	20.3
35.817			21.8
41.861	30.0	27.2	23.6
42.510	26.9	29.3	27.7
47.915	29.4	26.2	22.5
59.324	28.3	28.7	21.8
Number of lines	(20)	(20)	(19)
Mean	—29.88	—28.42	+23.16
Scale Corr.	+ .04	+ .04	— .03
Systematic Corr.	— .22	— .22	— .22
v_s	—30.06	—28.60	+22.91
Reduction to ⊙	+29.03	+27.33	—25.21
Observed V	— 1.03	— 1.27	— 2.30

Mean V = —1.53 km. Mean J. D. 2416969.09

Epoch 1905.33

a Trianguli Australis R. A. $16^h\ 38^m1$ Dec. — 68° 51′

Magn. 1.9 Type K2M

Date	1904 Feb. 29.88	1904 Aug. 10.57	1905 Feb. 9.87	1905 Aug. 8.52
Julian day	6540.88	6703.57	6886.87	7066.52
Plate number	202 IV	385 III	590 IV	766 II
Photographed by	W.	W.	W.	P.
Measured by	A.	A.	P.	A.
λ				
4238.980				+14.1
39.525			—22.5	
39.965				13.6
45.435	—25.7	+16.1		12.7
46.160	24.4	12.7		12.2
46.968	23.1		19.2	12.8
47.584				13.2
50.287			19.4	11.2
50.962			20.2	10.8
54.505				11.2
57.815			21.1	
58.500				13.9
65.374			22.7	
67.543			26.6	
68.866	22.5		20.4	13.3
71.325				16.0
74.935				14.2
78.390				13.1
82.565			16.3	17.7
83.169			22.7	11.5
86.627			17.8	
87.605			21.4	11.6
88.162				12.5
92.304				15.5
93.239	20.6			14.2
94.273				11.0
4300.211				16.3
06.921				10.2
13.034				11.9
14.357				13.6
18.867	21.9	15.0	18.9	14.6
21.898	25.7			13.1
25.195			21.2	14.7
25.978			17.1	14.2
28.101	24.8		21.5	11.6
30.189	21.1	14.2	19.1	17.1
30.866			16.8	
31.795		11.2		11.7
32.921				12.8
34.101	22.4	14.8		13.8
35.000	22.0			12.1
37.216			22.1	14.8
39.723	24.7			13.2
40.634				15.4
43.402		14.5	24.3	13.8
44.625	25.4	13.4		12.6
46.725				15.7
47.464	23.8		21.6	13.2
49.150	25 4	15.6	21.7	11.8

a Trianguli Australis—(Continued)

Date	1904 Feb. 29.88	1904 Aug. 10.57	1905 Feb. 9.87	1905 Aug. 8.52
4352.012				12.4
52.990	23.1	15.9		11.7
55.294	25.2		23.7	13.7
59.784	21.2		20.4	16.0
69.924	20.8	15.3		16.1
71.363				10.0
75.119			21.9	14.4
76.107	22.5		20.2	11.2
79.396	23.9	11.7	21.6	11.1
83.720				13.4
88.629			17.9	
89.413	21.3	14.4	19.7	15.2
90.143	23.3		20.6	13.5
91.152	20.4			11.7
95.298		14.0		9.5
4400.675				12.6
01.611	22.8	15.2		12.3
06.810	24.3		22.2	11.7
07.850	21.0	18.8		14.0
08.571				13.5
11.240				14.4
15.312				14.9
16.752				12.5
17.857			19.3	
18.542		14.9		14.3
27.444	22.6	14.0		13.6
28.711			24.8	10.6
30.785			24.2	
33.414				14.2
34.060				12.5
35.817			21.0	11.7
41.861			24.9	13.4
42.510		16.0	20.3	15.6
43.273				12.2
43.976			22.2	16.6
47.915	22.7	15.5	20.6	13.3
57.656				14.1
59.324	23.6			15.5
60.486				11.0
66.789	24 9	12.2	18.4	13.0
68.745	24.3	13.2	23.3	13.3
76.214			21.7	
Number of lines	(32)	(22)	(42)	(81)
Mean	—23.17	+14.48	—21.04	+13.27
Scale Corr.	+ .02	+ .05	+ .02	— .03
Systematic Corr.	— .22	— .22	— .22	— .22
v_s	—23.37	+14.31	—21.24	+13.02
Reduction to ⊙	+20.56	—17.49	+18.34	—17.02
Observed V	— 2.81	— 3.18	— 2.90	— 4.00

Mean V = —3.22 km. Mean J. D. 2416799.46

Epoch 1904.87

η Arae R. A. $16^h\ 41^m1$ Dec. — 58° 52′

Magn. 3.7 Type K5M

Date	1904 Mar. 11.85	1904 Mar. 13.85	1905 Apr. 4.81	1905 Aug. 23.53
Julian day	6551.85	6918.85	6940.81	7081.53
Plate number	237 III	634 III	682 IV	778 II
Photographed by	P.	P.	W.	P. & W.
Measured by	A.	P.	P.	A.
λ				
4239.525		—14.5	—13.4	
41.287			11.4	
46.968		15.1	12.7	
50.287		10.3	11.5	
65.374		15.9	11.3	
68.866		12.0	12.5	
4318.867			9.1	
25.195			11.4	
28.101	—14.6	12.7	10.4	+32.2
30.189		9.6		
31.795			14.1	33.8
32.921	16.4			
34.101	15.2			33.9
35.000			.	32.9
37.216		13.9	14.4	
38.430		13.4		
39.723	14.1	16.2	13.0	32.0
40.634		12.5	12.2	
44.625	15.8			34.6
47.464		15.1	11.3	35.0
49.150		13.9		
52.990	12.8			33.6
55.294	12.6	14.8	13.3	
59.784		11.6	10.7	36.7
69.924				32.9
71.363	13.1			32.9
75.119		15.3	14.2	30.3
76.107		14.6	11.2	34.6
79.396	12.8	13.9	13.2	34.3
89.413		12.8	9.7	31.2
90.143	12.8	12.8	12.2	33.3
91.152				32.9
95.298	16.9			33.1
4400.675				33.9
01.611	11.7			33.2
06.810	13.2	13.3	13.5	
07.850	14.2			33.3
16.752	14.5			33.3
27.444	12.8			33.6
28.711		16.0	12.8	30.0
35.244				34.3

η *Arae*—(Continued)

Date	1904 Mar. 11.85	1904 Mar. 13.85	1905 Apr. 4.81	1905 Aug. 23.53
4435.817		14.6	11.6	31.3
38.006		15.8	14.7	
41.861	11.6	15.5	12.9	31.9
42.510	10.4	14.4	12.0	35.7
43.976		12.6	11.8	
47.915	13.4	12.4	12.8	
51.752		12.9	11.9	
53.486			13.9	
55.485			13.4	
57.656	12.7			32.5
59.324				34.0
60.486	13.5			32.1
66.789	11.9	11.7	12.6	32.7
68.745	16.6		13.5	35.2
76.214		17.5	14.6	
Number of lines	(23)	(31)	(35)	(33)
Mean	—13.64	—13.79	—12.43	+33.24
Scale Corr.	.00	— .01	.00	— .06
Systematic Corr.	— .22	— .22	— .22	— .22
v_s	—13.86	—14.02	—12.65	+32.96
Reduction to ⊙	+24.20	+24.12	+21.55	—22.87
Observed V	+10.34	+10.10	+ 8.90	+10.09

Mean V = +9.86 km.

Mean J. D. 2416873.26
Epoch 1905.07

ε *Scorpii* R. A. 16h 43m7 Dec. — 34° 7′

Magn. 2.4 Type K

Date	1904 Mar. 3.84	1904 May 31.65	1905 Apr. 15.79	1905 Aug. 11.59
Julian day	6543.84	6632.65	6951.79	7069.59
Plate number	210 III	336 III	696 IV	769 III
Photographed by	P.	P.	P.	W.
Measured by	P.	P.	P.	A.
λ				
4231.183	—30.7			
33.772			—25.6	
38.980				+24.7
39.965				23.6
41.285	27.5			
45.435				23.4
46.160				23.9
46.968	30.9	— 7.5	24.5	22.1
47.584				21.9
50.287			24.6	22.0
50.962			23.6	21.7
54.505			23.2	21.3
57.815			21.9	
63.290	27.4		20.6	
65.374	28.4			
68.866		3.8	23.3	21.7
71.325				22.2
74.935				23.8
78.390				24.1
86.627	27.2		20.8	
87.605			23.6	
93.239				28.0
94.273				22.6
4306.921				23.5
13.771	26.0			
14.357				22.5
18.867	28.6	5.7	25.5	22.8
25.195			26.1	25.3
25.978				22.2
28.101	31.3		21.5	24.4
30.189			21.6	
31.795		1.7		
34.101				24.2
35.000				22.4
37.216	32.4	1.9	25.3	24.6
37.725			22.2	
38.430			18.8	
38.854			19.7	
39.723				23.1
40.634	33.1	4.2	22.0	24.5
41.530		8.0		
43.372	27.9			
44.625				24.3
47.464	32.8		26.5	
49.150			21.5	
52.012				24.0
52.972				24.1
55.294	35.1	6.8	22.8	
59.784	30.5	2.7	23.4	24.6
66.061			22.4	

ε Scorpii—(Continued)

Date	1904 Mar. 3.84	1904 May 31.65	1905 Apr. 15.79	1905 Aug. 11.59
4369.924				23.1
71.363				24.2
75.119			26.7	
76.107	29.9	6.6	21.7	22.1
79.396	32.3	6.2		23.0
88.571	27.8		20.0	
89.413	31.3		23.7	
90.118	31.7	6.4		24.5
91.152				23.6
95.270				23.8
99.907		3.9	23.6	
4400.675				22.8
01.611				21.6
06.810	31.9	4.3	25.9	23.0
07.850				24.6
08.571				23.6
27.444				23.9
28.711	32.2	3.9	26.8	
34.060				24.2
35.214				24.0
35.817	30.2	1.1	27.4	
38.006			28.7	
41.861	34.2		28.3	21.7
42.510	30.8	4.3	23.5	22.3
43.976			25.5	
47.915	27.8	3.4	22.2	21.3
51.752	28.0		25.0	
57.656				23.6
59.324				22.6
60.480				22.4
61.818	32.2		24.6	
66.789	29.6	3.9	30.2	21.5
68.673	28.7		24.8	23.8
76.214			26.4	
82.376		2.9		
85.846	29.2			
89.911			24.0	
4501.445		8.5		
12.906	29.0	4.3		
Number of lines	(32)	(22)	(43)	(53)
Mean	—30.21	— 4.64	—23.95	+23.30
Scale Corr.	+ .06	— .01	— .05	— .04
Systematic Corr.	— .22	— .22	— .22	— .22
v_s	—30.39	— 4.87	—24.22	+23.04
Reduction to ⊙	+29.55	+ 2.25	+22.11	—26.26
Observed V	— 0.84	— 2.62	— 2.11	— 3.22

Mean V = —2.20 km. Mean J. D. 2416799.47
Epoch 1904.87

μ^2 Scorpii R. A. $16^h\ 45^m6$ Dec. — 37° 51′

Magn. 3.6 Type B2A

Date	1904 Apr. 7.81	1905 Apr. 1.81	1905 Aug. 3.51	1905 Aug. 30.52
Julian day	6578.81	6937.81	7061.51	7088.52
Plate number	284 III	672 III	755 II	789 II
Photographed by	P.	P.	W.	W.
Measured by	W.	P.	W.	W.
λ				
4267.280		—25	+15	
4340.634	—14	25	17	+28
88.100	23	31	24	25
4471.693	19	14	33	29
Number of lines	(3)	(4)	(4)	(3)
Mean	—18.7	—23.8	+22.2	+27.3
Scale Corr.	0.0	0.0	0.0	0.0
Systematic Corr.	— .2	— .2	— .2	— .2
v_s	—18.9	—24.0	+22.0	+27.1
Reduction to ⊙	+24.3	+25.9	—23.5	—28.3
Observed V	+ 5.4	+ 1.9	— 1.5	— 1.2

Mean V = +1.4 km. Mean J. D. 2416916.66

Epoch 1905.19

This star probably has a variable velocity. Dr. Curtis has secured two plates for the purpose of confirming the variation. His observations are:

Date	Velocity	Measured by
1907, March 25	— 2	Curtis
April 26	+ 8	Paddock

ζ² Scorpii R. A. 16ʰ 47ᵐ6 Dec. — 42° 12′

Magn. 3.8 Type K5M

Date	1904 Mar. 23.84	1904 May 16.69	1905 Mar. 18.83	1905 Aug. 8.62
Julian day	6563.84	6617.69	6923.83	7066.62
Plate number	261 III	324 IV	649 IV	767 III
Photographed by	P.	P.	P.	P.
Measured by	P.	P.	P.	A.
λ				
4238.980				+ 4.1
39.965				5.1
41.285	—43.0			
45.435				3.8
46.160				5.2
46.968	42.9		—46.5	3.5
47.584				6.0
58.500				4.1
65.374	42.3		46.5	1.9
68.866	42.0		43.6	3.3
86.627			44.0	
87.605			47.3	
4313.034			45.0	
13.771			48.4	
18.867	48.3	—31.6	46.0	4.5
21.898				3.3
28.101	46.7		45.6	6.1
30.189			42.5	
31.795		27.2		
32.921				2.9
34.101				5.8
35.000				3.8
37.216			46.8	3.2
38.084	44.7			
39.723				4.5
40.634	45.8		51.2	
41.167	47.0			
41.530	44.9			
43.431		27.6		
44.625				5.6
46.725			43.1	
47.464			44.6	
47.705	43.4			
49.150	42.9			
52.012				3.8
52.990				4.3
55.294		25.2	47.5	
59.784	42.4	25.5	45.6	4.7
69.924		24.4		2.8
71.363				5.0
75.119	45.4			

ζ^2 *Scorpii*—(Continued)

Date	1904 Mar. 23.84	1904 May 16.69	1905 Mar. 18.83	1905 Aug. 8.62
4376.107	40.8	31.0	43.2	3.2
79.396	44.0	27.4	47.2	4.9
89.413	43.8		47.2	
90.143	42.6	28.4	47.0	3.5
95.298				2.3
4400.675				3.2
01.611				4.8
06.810	46.4	30.9	45.4	3.7
07.850				3.3
08.571				3.3
16.752				6.2
17.857			45.7	
27.444				4.8
28.711	46.9	33.0	44.0	
30.785		33.7		
32.736	40.2			
33.414	41.7			
34.060				3.1
35.244				4.3
35.817	45.7		50.8	0.4
38.006			52.3	
41.861			51.3	3.2
42.510	44.4	27.4	45.3	5.0
43.976	45.4			
47.915	43.3	29.7	45.3	4.1
51.752			46.9	
54.958				4.7
57.656				4.8
59.324				4.8
60.486				5.0
61.818	46.0			
66.789	44.5		47.7	3.6
68.745	45.5	35.0	46.4	0.5
76.214			44.3	
82.376	42.9	31.5		
4501.445	43.9			
12.906	42.5			
Number of lines	(32)	(16)	(32)	(46)
Mean	—44.13	—29.34	—46.38	+ 4.00
Scale Corr.	+ .01	— .01	— .03	— .01
Systematic Corr.	— .22	— .22	— .22	— .22
v_s	—44.34	—29.57	—46.63	+ 3.77
Reduction to ☉	+26.44	+ 9.92	+27.76	—24.24
Observed V	—17.90	—19.65	—18.87	—20.47

Mean V = —19.22 km.

Mean J. D. 2416793.00
Epoch 1904.85

ζ Arae R. A. $16^h\ 50^m3$ Dec. — 55° 50′

Magn. 3.1 Type K5M

Date	1904 Mar. 9.90	1904 June 1.64	1905 Mar. 12.85	1905 Apr. 26.71
Julian day	6549.90	6633.64	6917.85	6962.71
Plate number	230 III	340 II	632 IV	715 III
Photographed by	P.	P.	P.	W.
Measured by	W.	W.	P.	P.
λ				
4238.970			—31.7	
41.287				—26.2
46.968			35.4	24.1
50.287			29.3	25.6
50.962			31.3	
65.374			32.2	27.7
68.866				22.2
86.627				20.3
87.605			31.6	23.6
4313.771			31.4	
16.962				20.5
18.867		—10.7	28.8	25.3
28.101		9.5	30.1	20.4
30.189				20.2
31.795			33.9	24.7
37.216			32.2	25.1
37.725				22.6
38.084				23.8
40.634			32.9	
46.725			29.3	
49.150				24.3
52.990		10.0		
55.294	—31.6		32.0	
59.784	36.1	6.3	28.0	21.7
69.924	32.2	3.9		
75.119			30.6	23.9
76.107			29.9	21.7
79.396	30.3	11.5	32.7	24.4
89.413				23.3
90.143			30.4	23.9
91.152	29.5			
95.298		10.0		
4406.810		4.6	32.0	24.2
27.444	29.3	11.0		
28.711	33.5	14.1		28.2
30.785				29.2
33.414			30.9	
35.817			33.3	24.8
41.861			35.2	23.3
42.510	29.8		31.3	23.1
47.915		12.3	31.3	22.2

ζ Arae—(Continued)

Date	1904 Mar. 9.90	1904 June 1.64	1905 Mar. 12.85	1905 Apr. 26.71
4459.324	28.2	4.8		
66.789		9.3	31.8	21.5
68.745	33.1	8.9	35.2	23.6
69.545	28.6	4.4		
76.214	34.9		32.7	24.9
82.376	32.4			
85.846	27.5		30.4	
89.911				20.3
Number of lines	(14)	(15)	(29)	(33)
Mean	—31.21	— 8.75	—31.65	—23.66
Scale Corr.	.00	— .01	+ .06	+ .01
Systematic Corr.	— .22	— .22	— .22	— .22
v_s	—31.43	— 8.98	—31.81	—23.87
Reduction to ⊙	+25.17	+ 3.44	+25.17	+17.04
Observed V	— 6.26	— 5.54	— 6.64	— 6.83

Mean V = —6.32 km.

Mean J. D. 2416766.02
Epoch 1904.78

β Arae R. A. $17^h\ 17^m.0$ Dec. — 55° 26′

Magn. 2.8 Type K2M

Date	1904 Mar. 12.88	1904 May 16.79	1905 Mar. 14.88	1905 Apr. 27.77
Julian day	6552.88	6617.79	6919.88	6963.77
Plate number	240 III	325 II	637 IV	718 IV
Photographed by	P.	P.	P.	P.
Measured by	P.	P.	P.	P.
λ				
4222.382	—26.8			
31.183	23.6			
39.525				—17.8
41.285	25.8			20.1
46.968	23.0		—29.6	17.9
50.287				18.5
50.962			26.3	17.6
57.815			24.5	
63.290			22.7	
65.374	27.4		23.6	
68.866	23.9		25.0	20.6
87.605	28.5		30.3	20.6
4316.962			22.3	
18.867	24.5	— 9.1	26.5	
28.101	25.4	15.5	26.2	18.8
30.189			24.6	
31.795	29.2		25.3	20.1
32.921			27.4	
37.216	27.4	15.0	22.8	19.8
38.430	25.7			
47.464	25.8		26.1	18.0
49.150	26.9		24.6	19.0
55.294		9.0	24.3	
59.784	22.2	9.9	23.2	17.7
76.107	28.0	12.8	24.1	18.3
79.396	25.7	11.9	27.4	22.2
88.629	25.4			20.8
89.413	26.3	12.0	26.0	18.0
90.143	28.8	9.1	22.7	18.5
4406.810	26.0		27.5	18.3
17.857	23.3	14.0		17.9
28.711	29.0		27.6	22.4
35.817			25.6	19.2
38.006			30.7	22.8
41.861	28.5	14.9	28.7	24.3
42.510		9.6	26.0	19.9
43.976			24.5	
47.008		8.3		
47.915	25.1	14.1	26.5	18.9
51.752			26.0	
66.789	29.4	13.2	25.9	16.9

β Arae—(Continued)

Date	1904 Mar. 12.88	1904 May 16.79	1905 Mar. 14.88	1905 Apr. 27.77
4468.745	27.9	12.5	28.0	24.2
76.214	29.9	17.7	24.7	21.5
82.376	25.3			
84.392	27.9	15.6		
85.846	24.6	10.4		
Number of lines	(31)	(19)	(34)	(29)
Mean	—26.36	—12.35	—25.80	—19.68
Scale Corr.	+ .02	.00	— .01	+ .01
Systematic Corr.	— .22	— .22	— .22	— .22
v_s	—26.56	—12.57	—26.03	—19.89
Reduction to ⊙	+25.40	+11.50	+25.38	+18.17
Observed V	— 1.16	— 1.07	— 0.65	— 1.72

Mean V = —1.15 km. Mean J. D. 2416763.58

Epoch 1904.77

υ Scorpii R. A. $17^h\ 24^m0$ Dec. — 37° 13′

Magn. 2.8 Type B3A

Date	1904 July 24.64	1904 Aug. 26.52	1905 Mar. 17.90	1905 Apr. 16.89
Julian day	6686.64	6719.52	6922.90	6952.89
Plate number	369 II	391 II	646 IV	701 II
Photographed by	W.	P.	P.	P.
Measured by	A.	A.	A.	A.
λ				
4267.280	+48.7	+28.2	—19.7	+12.8
4340.634	43.2	18.6	22.6	13.6
47.555			13.0	
49.560			8.7	
88.100	44.1	18.2	18.0	9.2
96.022	44.5			
4415.035				7.1
17.129			11.9	10.8
37.718	44.0	19.9	8.9	1.0
47.188			14.8	
65.589			19.7	
69.832	41.2			17.6 wt. ½
71.693	48.7	30.0	14.7	+ 1.4
81.375	44.2	37.5	18.8	— 1.5
Number of lines	(8)	(6)	(11)	(9)
Mean	+44.82	+25.40	—15.53	+ 7.43
Scale Corr.	+ .20	+ .17	+ .01	.00
Systematic Corr.	— .22	— .22	— .22	— .22
v_s	+44.80	+25.35	—15.74	+ 7.21
Reduction to ⊙	—18.13	—27.15	+29.02	+24.02
Observed V	+26.67	— 1.80	+13.28	+31.23

Velocity variable.

Observations of *υ Scorpii* made by Dr. Curtis in 1907 fully confirm the variation of the radial velocity. His measures are as follows:

Date	Velocity
1907, June 23.74	+ 5 km.
Sept. 11.52	+ 25 km.
29.51	+ 38 km.
Oct. 18.51	+ 26 km.

η Pavonis R. A. $17^h\ 35^m\!.9$ Dec. — 64° 41′

Magn. 3.6 Type K

Date	1904 Mar. 22.86	1904 Sept. 12.59	1905 Mar. 16.78	1905 Aug. 22.61
Julian day	6562.86	6736.59	6921.85	7080.61
Plate number	258 IV	415 II	643 IV	776 III
Photographed by	P.	W.	P.	W.
Measured by	W.	W.	P.	P.
λ				
4238.970			—29.7	+11.0
46.968			29.4	11.7
50.287			29.9	10.1
50.962			29.2	9.4
54.505			28.6	10.7
57.815			31.2	
74.935			29.1	12.2
78.390			31.8	12.0
82.565			28.2	14.9
83.169			31.5	
87.605			31.3	11.4
94.273				8.3
4313.034			31.7	9.5
13.771	—29.8		29.3	12.6
18.867	28.0		28.8	11.6
25.195			28.2	11.3
28.101	31.6	λ4450 central. System II	32.0	12.3
31.795	26.0		32.9	
37.216			29.5	10.1
40.634	32.0		31.1	
52.972	29.7			11.0
55.294			32.0	
59.784	26.0		31.1	
69.924	29.8		30.6	
71.363				9.7
75.119			29.5	11.2
76.107			30.9	9.0
79.396	30.2		32.9	7.7
90.118			32.7	10.3
91.152			31.5	11.1
95.270	32.6		29.4	11.3
99.907			32.8	
4406.810	33.2		32.0	9.8
07.850	29.5		29.4	11.9
11.240			27.4	
17.857			31.1	
27.444	30.9			
33.414			28.9	
35.817	34.9		32.6	12.3
41.861	33.1		32.8	13.2
42.510	31.4		28.4	12.4

η *Pavonis*—(Continued)

Date	1904 Mar. 22.86	1904 Sept. 12.59	1905 Mar. 16.78	1905 Aug. 22.61
4443.976	31.0	λ4450 central. System II.	31.5	
47.915	28.9		30 3	10.7
59.324	33.1			
66.789	34.0			10.5
68.673	29.2		29.2	14 9
76.214	36.0		30.8	13.5
82.376			30.7	10.5
Number of lines	(22)	(36)	(42)	(34)
Mean	—30.95	+14.50	—30.52	+11.18
Scale Corr.	.00	— .32	+ .01	— .02
Systematic Corr.	— .22	.00	— .22	— .22
v_s	—31.17	+14.18	—30.73	+10.94
Reduction to ⊙	+22.39	—22.24	+22.56	—19.86
Observed V	— 8.78	— 8.06 wt. ½	— 8.17	— 8.92

Mean V = —8.54 km.

Mean J. D. 2416838.18

Epoch 1904.98

ι^1 *Scorpii* R. A. $17^h\ 40^m.6$ Dec. — 40° 5′

Magn. 3.1 Type F5G Pec.

Date	1904 May 31.78	1904 June 24.74	1905 Mar. 29.89	1905 June 12.75
Julian day	6632.78	6656.74	6934.89	7009.75
Plate number	338 II	358 III	667 II	733 II
Photographed by	P.	W.	W.	P.
Measured by	A.	P.	P.	A.
λ				
4246.968	—29.0		— 48.1	
50.287	32.5	—27.7	57.4	—33.2
50.945	37.0	26.3	57.2	27.6
54.505	38.6	23.2	51.8	31.0
58.370	32.8	22.4		32.0
60.640		25.3	55.1	
71.325	33.7			
71.934	37.3			
74.935	37.3	24.0		24.8
78.390	40.4	26.7		36.8
82.565		21.7	56.3	
84.382		25.9		
88.083	40.0	25.7		32.8
94.273	37.6	21.1		
4300.211	31.9	18.8	55.1	30.7
03.443	37.7	24.2	58.0	32.3
13.034	39.3	21.5	55.2	27.5
14.357	32.0			
16.962			56.0	
21.000	35.2	19.9		30.3
25.195	37.4	28.7	57.2	31.5
25.939	35.7	22.5	55.8	24.5
38.084	39.3	22.3	53.2	
40.634			47.8	
44.481	38.0			
52.012	39.1			33.4
59.784			49.7	
69.651	38.3		60.8	
71.363	40.2			
76.107		27.0	59.5	26.2
83.720	33.9	21.4	54.1	29.1
85.144		22.9		
87.007	40.5			27.9
91.152				29.4
95.242	35.0	19.4		29.1
99.907	31.4			
4400.617	35.6			36.9
04.927	34.0	22.5	58.2	27.7
07.850		26.7		
11.240	34.0	20.7		38.2
16.985	33.2	22.0		29.5

ι^1 *Scorpii*—(Continued)

Date	1904 May 31.78	1904 June 24.74	1905 Mar. 29.89	1905 June 12.75
4417.857			55.5	
41.861	31.5		51.5	
43.976		21.1	53.9	
50.654	33.5	21.3		27.6
54.958				35.3
64.631	37.9			29.8
66.727	35.2	23.5		
68.824	36.5			
76.214			54.4	
81.364	30.7	23.4	54.7	
Number of lines	(37)	(30)	(24)	(26)
Mean	—35.76	—23.33	—54.85	—30.58
Scale Corr.	— .08	— .04	— .05	— .02
Systematic Corr.	— .22	— .22	— .22	— .22
v_s	—36.06	—23.59	—55.12	—30.82
Reduction to ⊙	+ 7.83	— 3.49	+27.94	+ 2.35
Observed V	—28.23	—27.08	—27.18	—28.47

Mean V = —27.74 km.

Mean J. D. 2416808.54
Epoch 1904.89

G Scorpii R. A. 17ʰ 43ᵐ0 Dec. — 37° 1′

Magn. 3.2 Type K2M

Date	1904 Mar. 15.88	1904 Apr. 22.81	1905 Apr. 16.81	1905 Aug. 25.61
Julian day	6555.88	6593.81	6952.81	7083.61
Plate number	248 III	308 IV	700 IV	784 II
Photographed by	W.	P.	P.	W.
Measured by	P.	P.	P.	A.
λ				
4199.267	— 2.1			
4217.720	— 0.4			
22.382	— 2.8			
31.183	— 1.2			
38.980				+50 2
39.965				50.7
45.435				51.1
46.160				50.7
46.968	— 0.1	— 0.5	— 0.4	50.5
47.591				49.9
50.287	— 5.8		+ 0.6	49 6
50.962	— 0.8	— 0.2	— 0.7	48.6
54.505				49.2
55.134	— 6.9			
57.815	— 5.2		— 0.3	52.0
58.500				52.7
63.290	— 0.6			
65.374			+ 1.2	
67.543	— 2.8		— 2.4	
68.866	— 4.5		— 1.1	52.5
71.325				48.9
71.934				47.4
74.935				51.3
78.390				49.8
82.565	— 1.1			
83.169	— 4.8		— 2.5	50.0
86.627			+ 4.0	
87.605	— 1.6		+ 1.0	51.8
88.162				49.8
92.304				49.3
93.272				51.8
94.273				51.5
4300.211				51.8
03.337			— 3.4	
06.921				51.3
13.034				50.8
13.771	0.0		+ 1.8	49.2
14.357				50.8
18.867	— 3.9	— 2.0	+ 0.3	51.9
21.898				52.9
25.195			+ 1.4	54.8

G *Scorpii*—(Continued)

Date	1904 Mar. 15.88	1904 Apr. 22.81	1905 Apr. 16.81	1905 Aug. 25.61
4325.978				52.4
28.101	— 4.4	+ 2.1	+ 0.9	51.8
30.189			+ 0.2	52.7
30.866		+ 0 9		
31.795		— 2.2		51.3
32.921				52.6
34.101				51.8
35.000				53.8
37.216	— 4.7	+ 5.1	+ 0.5	51.1
38.084			+ 1.8	49.8
38.430			+ 0.4	
38.854			+ 3 9	
39.723				50.0
40.634	— 4 9		— 2.5	49.7
41.530	— 1.2			
43 402	— 4.8		+ 0.7	53.4
44.625				50.0
47.464	— 6 6		— 6.7	49.9
47.705	+ 0.2	+ 5.2		
49.150	— 4.3	+ 0.2	+ 0.5	51.1
52.012				51.0
52.990				51.2
55.294			+ 1.3	49.8
59.784	— 1.7	— 0.2	— 2.6	50.0
66.061			— 3.1	
67.749	+ 1.0			
69.924	— 2 9			51.7
71.363				50.8
75.119			— 1.7	49.9
76.107	— 3 4		+ 0.7	51.4
79.396	— 4.7	— 1.2	— 1.3	50.2
83.720				49.6
89.413	— 3 8		+ 1.5	
90.143	— 6.1	— 1.6	— 1.3	49.4
91.152				50.8
95.298				48.8
4400.675				48.0
01.611				51.2
04.927				48.4
06.810	— 5.4	— 2.0	— 0.4	51.1
07.850				52.3
08.571				51.5
11.240				54.5
15.312				49.4
16.752				54.6
17.857	— 4.7			
27.444				51.4
28.711	— 2.6	— 0.3	— 2.6	51.0

G *Scorpii*—(Continued)

Date	1904 Mar. 15.88	1904 Apr. 22.81	1905 Apr. 16.81	1905 Aug. 25.61
4430.785		— 3.2		
33.414	0.0			53.5
34.060				53.0
35.244				52.3
35.817	— 4.6		+ 0.3	50.2
41.861	— 6.9	+ 3.4	— 1.1	52.7
42.510	— 2.1	+ 2.9	0.0	53.1
43.273				52.4
43.976			+ 2.2	53.7
47.915	— 5.6		+ 0.6	49.8
51.752			— 0.4	
54.958				52.0
57.656				52.8
59.324				52.6
60.486				49.9
61.818	— 2.2			
66.789	— 3.7		— 5.9	53.4
68.745	— 7.2	— 4.0	— 2.9	50.1
76.214			— 0.8	
4501.445		— 1.4		
Number of lines	(43)	(19)	(44)	(84)
Mean	— 3.30	+ 0.05	— 0.43	+51.11
Scale Corr.	.00	.00	.00	— .11
Systematic Corr.	— .22	— .22	— .22	— .22
v_s	— 3.52	— 0.17	— 0.65	+50.78
Reduction to ⊙	+29.19	+23.57	+25.27	—26.40
Observed V	+25.67	+23.40	+24.62	+24.38

Mean $V = +24.52$ km.

Mean J. D. 2416796.53
Epoch 1904.86

π Pavonis R. A. 17h 58m9 Dec. — 63° 40′

Magn. 4.4 Type A5F

Date	1904 Apr. 4.83	1904 June 8.70	1905 Apr. 22.79	1905 Sept. 6.58
Julian day	6575.83	6640.70	6958.79	7095.58
Plate number	274 III	348 II	707 III	795 III
Photographed by	P.	W.	P.	W.
Measured by	P.	W.	P.	P.
λ				
4250.287			—42.8	+ 2.9
50.945	—42.6		39.8	+ 4.2
52.80			41.3	
54.505	44.5	—23.0	37.1	+ 6.9
58.33			38.4	+ 1.7
62.086			38.8	
74.935	41.3	17.5	37.5	+ 4.4
78.34			38.2	
82.565	42.5		41.3	+ 1.0
83.169	41.0			
84.382			39.2	
88.06			35.8	+ 7.1
96.75			34.6	
4300.211		23.6		+ 8.2
03.337			35.6	
13.034	39.5	27.6	37.9	+ 1.7
25.939	45.6	23.5	40.7	+ 0.6
40.634			34.5	
75.119	45.3	24.1	39.6	+ 1.1
83.720	42.9	23.3	37.4	+ 3.0
85.56			37.9	
91.152	43.4			
95.242	44.4		37.7	+ 3.7
99.907	45.0		33.6	
4404.927	44.4	18.4	39.4	+ 4.3
07.850			38.4	
15.312	46.7		37.5	+ 1.2
16 985	43.5		39.2	— 2.7
17.857			36.2	+ 3.0
27.444		25.7		
30.785			37.0	
35.817			40.5	
42.510		23.5	37.4	
43.976			38.0	+ 3.5
47.915	44.2		38.7	+ 3.3
50.654			35.3	+ 3.6
66.727	44.3			+ 4.4
68.623	44.8	19.5	37.6	— 1.5
76.214			38.4	+ 1.3
81.375	42.5		36.0	+ 0.8
Number of lines	(19)	(11)	(35)	(24)
Mean	—43.60	—22.70	—37.98	+ 2.82
Scale Corr.	— 0.01	— 0.04	+ 0.03	0.00
Systematic Corr.	— .22	— .22	— .22	— .22
v_s	—43.83	—22.96	—38.17	+ 2.60
Reduction to ⊙	+22.10	+ 4.75	+19.32	—21.86
Observed *V*	—21.73	—18.21	—18.85	—19.26

Mean *V* = —19.51 km. Mean J. D. 2416817.78

Epoch 1904.92

γ Sagittarii R. A. $17^h\ 59^m4$ Dec. — 30° 26′

Magn. 3.1 Type K

Date	1904 Apr. 5.83	1904 June 22.77	1905 Apr. 23.82	1905 Aug. 30.60
Julian day	6576.83	6654.77	6959.82	7088.60
Plate number	278 III	353 III	710 IV	790 III
Photographed by	P.	P.	P.	W.
Measured by	A.	A.	P.	A.
λ				
4239.965				+47.1
46.160				47.4
46.968			— 3.2	46.1
50.287			— 0.8	45.7
50.962			— 4.4	45.6
54.505			— 4.0	47.2
65.374			+ 0.8	
68.866			— 3.4	
74.935				47.7
82.565			— 3.7	
83.169			— 9.6	
86.627			— 1.8	
87.605			— 2.0	
92.304				46.2
93.239				46.1
94.273				46.6
4306.921				46.7
13.771			— 6.0	
14.357		+20.4		47.0
18.867		23.2	— 3.7	
25.195				48.9
25.978				45.4
28.101		22.5	— 1.6	
30.189			— 4.6	
34.101		23.5		
37.216			— 6.6	46.7
39.723		24.3		
40.634	— 4.2	26.3	— 9.0	49.2
41.530			— 2.0	
44.625				46.5
49.150	9.0		— 6.2	
52.012		24.0		46.9
52.972	6.6	24.9		46.8
55.294			— 3.6	
59.784	5.0	21.6	— 5.2	49.1
69.924	7.8	24.4		47.2
71.363	5.3	24.1		48.2
76.107		19.0	— 5.0	46.1
79.396	9.1		— 5.1	
83.720				47.1
89.413			— 5.0	

γ Sagittarii—(Continued)

Date	1904 Apr. 5.83	1904 June 22.77	1905 Apr. 23.82	1905 Aug. 30.60
4390.118			— 7.3	
95.270	4.0	26.0		44.9
99.907			— 6.2	
4400.675				46.3
01.611				46.1
04.927		23.4		46.7
06.810	8.5		— 4.1	
07.850	4.8			46.0
08.571	6.2			47.4
15.312	6.4	24.8		44.1
27.444	9.2	23.1		46.7
28.711			— 6.0	
30.785			— 6.8	
32.736			— 3.8	
35.214				47.9
35.817			— 6.1	
41.861			— 6.0	
42.510	3.5		— 2.8	46.3
43.273	5.8			
43.976			— 1.2	
47.915	6.4	24.1	— 5.5	45.7
54.958	7.6			
57.656				46.8
59.324	6.2	26.2		45.1
60.486				45.7
66.789		23.7	— 5.7	45.2
68.673	8.3	26.0	— 3.5	48.1
76.214			— 6.1	
Number of lines	(19)	(20)	(37)	(40)
Mean	— 6.52	+23.78	— 4.53	+46.66
Scale Corr.	.00	+ .13	.00	— .12
Systematic Corr.	— .22	— .22	— .22	— .22
v_s	— 6.74	+23.69	— 4.75	+46.32
Reduction to ☉	+28.61	— 0.79	+24.81	—27.30
Observed V	+21.87	+22.90	+20.06	+19.02

Velocity variable.

The variable velocity of this star was suspected from the observations given above. The object is within the reach of the instruments at Mt. Hamilton, and has been observed here for the purpose of confirming the variation. An additional observation was also made in Chile.

Date			Velocity	Photo. by	Measured by
1907,	June	25.77	+ 18.1	Paddock	Paddock
1910,	May	16.95	+ 24.5	Young	Miss Hobe
1910,	July	10.80	+ 23.4	Merrill	Miss Hobe
1910,	July	22.80	+ 23.3	Wilson	Wilson

All the observations taken together establish conclusively the star's variation. (See note on page 80.)

η Sagittarii R. A. $18^h\ 10^m.9$ Dec. — 36° 47′

Magn. 3.2 Type Mb

Date	1905 Mar. 15.87	1905 Apr. 17.80	1905 Aug. 20.63	1905 Aug. 31.60
Julian day	6920.87	6953.80	7078.63	7089.60
Plate number	640 II	705 II	773 III	792 II
Photographed by	W.	W.	P.	W.
Measured by	A.	P.	A.	A.
λ				
4238.980	—31.5	—25.2		
39.965				+26.0
45.435	31.1		+25.1	28.8
46.968		24.9	22.1	27.3
47.584	29.4		24.8	27.4
50.287	27.3	27.2		
50.962	29.4	27.0		27.2
58.500			25.3	29.1
65.320	30.0	24.7	25.1	28.5
68.866			24.1	28.0
83.169		25.4		
87.605	29.4	24.4		
4300.211		24.6		
00.732		27.2		
13.034		22.3		
18.867	31.9	26.2	25.9	25.9
25.195	28.3	26.8		30.2
25.978		27.2		
28.101	31.2	23.0	25.0	23.9
31.795	33.1	23.3		
32.921	28.1		27.2	
34.101	29.1			28.4
37.216	28.3	27.1		27.2
39.723	29.3			26.7
40.634		28.6		
44.625	27.5		26.1	29.5
46.725		29.0		
51.973			25.6	26.8
53.008	30.7		25.9	27.7
55.294		28.5		
59.784	28.1	24.2	27.7	29.2
69.924	31.6	29.3	24.9	
71.363			26.4	27.1
75.119	29.9	27.5		
76.107	28.5	26.0	25.0	27.3
79.396	29.2	27.1	24.8	27.0
83.720		28.4		
88.629		21.6		
89.413				27.4
90.168	29.5	27.3	23.8	27.3
91.152		26.5		
95.298		25.7	25.5	

η Sagittarii—(Continued)

Date	1905 Mar. 15.87	1905 Apr. 17.80	1905 Aug. 20.63	1905 Aug. 31.60
4400.675				27.4
04.927		21.7		
06.810	29.1	25.4	24.0	27.8
07.850	30.1	27.7		24.3
08.571			27.5	26.0
11.240	31.3	25.7		
16.752	30.7		24.3	26.2
18.542		26.2		
27.444	30.4		24.6	25.0
30.785		29.1		
34.060	29.8			
35.244	31.4			
41.861	30.0	25.5		28.3
42.510	30.7	24.4	26.4	29.7
43.976		26.0		
47.915	31.8	25.4	22.9	27.8
57.656			26.3	26.8
59.324			21.6	28.2
60.486			23.7	25.1
66.789	29.3	25.9	25.1	27.7
68.745	29.9	24.7	27.5	29.7
76.214		29.3		
82.376		30.0		
Number of lines	(35)	(43)	(30)	(37)
Mean	—29.91	—26.12	+25.14	+27.40
Scale Corr.	+ .02	— .01	— .01	— .09
Systematic Corr.	— .22	— .22	— .22	— .22
v_s	—30.11	—26.35	+24.91	+27.09
Reduction to ⊙	+29.00	+26.40	—23.83	—26.49
Observed V	— 1.11	+ 0.05	+ 1.08	+ 0.60

Mean V = +0.16 km.

Mean J. D. 2417010.72
Epoch 1905.45

δ Sagittarii R. A. $18^h\ 14^m 6$ Dec. — 29° 52′

Magn. 2.8 Type K

Date	1905 Mar. 22.89	1905 May 3.77
Julian day	6927.89	6969.77
Plate number	655 IV	724 III
Photographed by	W.	W.
Measured by	P.	P.
λ		
4246.968	—51.6	
50.287	51.7	
50.962	49.1	
57.815	49.9	
65.374	50.0	
68.866	49.6	
87.605	49.8	
4316.962	44.2	
28.101	49.8	—42.9
30.189	46.0	38.1
30.866		36.6
31.795	51.5	41.7
37.216	51.6	43.8
38.854	48.2	
40.634	53.2	
43.402		43 2
47.464	48.5	42 4
49.150	50.5	38.6
55.294	50.8	43.7
59.784	48.9	
66.061	47.0	
75.119	49.5	
76.107	45.3	40.0
79.396	51.3	43 6
88.629	47.6	44.2
89.413	49.9	39.7
90.118	49 2	42.2
99.907	51.8	
4406.810	50.7	44.7
25.608	46.4	
28.711	49.4	44.4
35.817	50.2	42.9
41.861	50.7	43.8
42.510	48.1	39.8
43.976	48.3	44.7
47.915	47.3	42.0
66.789	48.5	46.6
68.673	48.5	41.1
76.214	51.3	44.7
89.911	47.5	
Number of lines	(38)	(24)
Mean	—49.30	—42.31
Scale Corr.	— .01	+ .05
Systematic Corr.	— .22	— .22
v_s	—49.53	—42.48
Reduction to ⊙	+29.78	+22.90
Observed V	—19.75	—19.58

Mean V = —19.66 km. Mean J. D. 2416948.83

Epoch 1905.28

ε Sagittarii R. A. $18^h\ 17^m 5$ Dec. — 34° 26′

Magn. 2.0 Type A

Date	1904 May 31.85	1904 Sept. 11.57	1905 Apr. 1.88	1905 Sept. 2.57
Julian day	6632 85	6735.57	6937.88	7091.57
Plate number	339 III	411 II	673 III	793 IV
Photographed by	P.	W.	P.	W.
Measured by	A.	A.	A.	A.
λ				
4340.634	—19.5	+24.3±	—48.5	+ 8.8
Scale Corr.	— .05	— .6	.0	.0
Systematic Corr.	— .22	— .22	— .22	— .22
v_s	—19.8	+23.5	—48.7	+ 8.6
Reduction to ☉	+11.51	—28.33	+29.08	—26.77
Observed V	— 8.3	— 4.8	—19.6	—18.2

Mean V = —12.7 km. Mean J. D. 2416849.47

Epoch 1905.01

a Telescopii R. A. $18^h\ 19^m6$ Dec. — 46° 1′

Magn. 3.8 Type B3A

Date	1904 Apr. 8.87	1904 Aug. 27.61	1905 Apr. 15.86	1905 Aug. 29.60
Julian day	6579.87	6720.61	6951.86	7087.60
Plate number	288 IV	397 III	697 II	787 II
Photographed by	P.	P.	P.	W.
Measured by	A.	A.	A.	A.
λ				
4267.280	—29.4	+16.8	—30.2	+32.6
4340.634		21.9	29.9	28.8
88.100	29.5	20.2	26.4	31.2
4437.718	39.8 wt. ½	27.8 wt. ½	29.5	22.2
71.693	27.2	28.8 wt. ½	25.2	29.5
81.375	23.3	20.9	24.5	25.4
Number of lines	(5)	(6)	(6)	(6)
Mean	—28.73	+21.62	—27.62	+28.28
Scale Corr.	— .04	+ .09	— .02	— .03
Systematic Corr.	— .22	— .22	— .22	— .22
v_s	—28.99	+21.49	—27.86	+28.03
Reduction to ⊙	+27.04	—24.41	+26.01	—24.78
Observed *V*	— 1.95	— 2.92	— 1.85	+ 3.25

Mean *V* = —0.9 km. Mean J. D. 2416834.98

Epoch 1904.97

Dr. Albrecht considers the range shown by his measures to indicate a probable variation in velocity.

ζ Telescopii R. A. $18^h\ 21^m.1$ Dec. — 49° 7′

Magn. 4.1 Type K

Date	1904 Apr. 15.85	1904 Sept. 14.59	1905 Aug. 21.62	1905 Sept. 7.60
Julian day	6586.85	6738.59	7079.62	7096.60
Plate number	292 III	420 II	774 II	797 IV
Photographed by	W.	W.	W.	W.
Measured by	A.	P.	A.	A.
λ		λ4450 central. System II		
4239.965				— 3.3
45.435	—55.7		— 8.4	3.0
46.160				3.3
46.968				5.8
47.584	56.6			3.2
50.287				3.9
50.962	56.0		11.5	3.8
54.505			10.2	
68.866	59.7		9.5	
74.935			9.5	2.6
92.304	59.2			
93.239				2.7
94.273	56.7		9.1	2.5
4306.921			8.5	4.5
14.357			9.7	3.1
18.867	58.9			3.8
25.195				2.1
28.101	53.1		7.9	5.3
37.216	52.4		7.1	
39.723	57.5			
40.634	52.7		9.3	
44.625			7.9	
52.012				2.0
52.972	53.4		7.5	2.5
59.784	54.1			5.1
69.924			8.0	
71.363	53.4		8.9	
76.107			8.6	3.4
79.396	60.4		9.7	
91.152				3.0
95.270	52.9		8.4	3.8
4401.611	54.8		5.8	3.5
06.810			9.0	5.8
07.850	56.4		6.5	5.3
08.571	56.0			2.2
15.312			11.2	
27.444	52.7		7.8	4.8
35.214			10.3	2.8
41.861				2.2
42.510	55.3		6.1	3.1
47.915	54.1			5.3

ζ Telescopii—(Continued)

Date	1904 Apr. 15.85	1904 Sept. 14.59	1905 Aug. 21.62	1905 Sept. 7.60
4450.324	59.3	λ4450 central. System I		1.9
60.486	58.9			
66.789	53.0			
68.673	54.8		6.9	3.5
Number of lines	(26)	(19)	(26)	(32)
Mean	—55.69	— 2.46	— 8.59	— 3.53
Scale Corr.	— .08	+ .01	.00	+ .01
Systematic Corr.	— .22	.00	— .22	— .22
v_s	—55.99	— 2.45	— 8.79	— 3.73
Reduction to ⊙	+24.99	—26.32	—21.87	—25.42
Observed V	—31.00	—28.77 wt. ½	—30.66	—29.15

Mean V = —30.06 km.

Mean J. D. 2416894.96
Epoch 1905.13

λ Sagittarii R. A. $18^h\ 21^m8$ Dec. — 25° 29′

Magn. 2.9 Type K

Date	1905 Apr. 5.89	1905 June 14.82
Julian day	6941.89	7011.82
Plate number	685 IV	736 IV
Photographed by	W.	P.
Measured by	P.	P.
λ		
4241.287	—70.4	
46.968	72.1	—48.6
50.287	74.9	49.1
50.962	74.8	47.8
54.505	73.3	47.4
63.290	69.2	
65.374	69.3	
67.543		50.9
68.866	71.0	43.7
82.565	71.7	
86.627	69.2	47.5
87.605	71.2	50.0
4313.771	70.7	47.9
18.867	70.4	50.7
25.195	71.1	
25.978	71.3	
28.101	71.4	48.4
30.189	70.1	
31.795		50.1
37.216	72.3	52.5
38.084	72.9	
38.854	68.9	
40.634	72.5	48.2
41.167	69.1	
41.530	74.6	44.8
43.402	72.9	47.3
59.784	73.2	50.2
75.119	75.3	47.3
76.107	70.9	48.8
79.396	72.4	50.8
88.629		48.7
89.413	76.6	50.2
90.118	72.6	50.8
99.907	71.1	48.1
4404.927	69.3	
06.810	72.7	48.9
17.857	69.7	
28.711	70.8	50.6
30.785	73.4	51.0
35.817	71.3	50.6
41.861	72.4	48.4

λ *Sagittarii*—(Continued)

Date	1905 Apr. 5.89	1905 June 14.82
4442.510	71.5	48.5
43.976	73.6	50.0
47.915	73.6	47.3
66.789	75.5	52.1
68.673	70.0	49.5
76.214	69.4	49.0
Number of lines	(44)	(35)
Mean	—71.83	—49.11
Scale Corr.	— .12	+ .05
Systematic Corr.	— .22	— .22
v_s	—72.17	—49.28
Reduction to ⊙	+29.32	+ 5.81
Observed V	—42.85	—43.47

Mean V = —43.16 km. Mean J. D. 2416976.86

Epoch 1905.36

ζ Pavonis R. A. $18^h\ 31^m4$ Dec. — 71° 31′

Magn. 4.1 Type K

Date	1904 Sept. 13.61	1905 Apr. 24.80	1905 July 22.75	1905 Aug. 24.63
Julian day	6737.61	6960.80	7049.75	7082.63
Plate number	418 II	713 IV	750 III	782 III
Photographed by	W.	W.	W.	P.
Measured by	W.	P.	P.	W.
λ	λ4450 central. System II			
4238.970		—33.0	— 8.2	
46.968		35.8	10.1	+ 1.6
50.287		33.1	10.3	+ 2.5
50.962		32 5	9.6	+ 0.6
54.505			9.4	+ 1.9
65.374		32.1		
74.935			7.6	+ 2.6
78.390			8.7	
83.169				— 1.7
87.605		35.3	7.0	+ 2.0
91.630		33.9		
4313.034		35.5	12.1	
13.771		36.1	10.4	— 1.0
18.867		32.6	7.8	— 1.2
25.195		32.4	9.0	+ 2.5
25.978				+ 0.1
28.101		32.7	6.7	+ 1.8
31.795		34.8		
37.216		35.8	10.0	+ 0.7
40.634		33.8	10.4	+ 0.4
41.530		33.5		
49.150				— 0.4
52.972			5.2	
59.784		37.3		— 2.2
71.363			8.6	
75.119				— 0.7
76.107		35.0	10.1	+ 2.2
79.396		39.1	10.2	— 0.1
90.118		36.5	8.2	
91.152		35.7	9.8	+ 4.3
95.270			8.1	— 1.6
99.907		36.1	7.7	
4404.927				+ 3.5
06.810		37.0	7.6	— 0.8
07.850		38.6	8.6	+ 2.3
18.542		32.8		
27.444				+ 0.8
30.785		35.4		
35.817			8.3	+ 2.0
41.861		37.9	8.5	— 1.2
42.510		34.1	5.9	+ 1.2

ζ Pavonis—(Continued)

Date	1904 Sept. 13.61	1905 Apr. 24.80	1905 July 22.75	1905 Aug. 24.63
4443.976	λ4450 central. System II.	32.3		
47.915		31.3	5.5	
66.789		33.2	7.7	
68.673		32.9	7.5	
76.214		32.1	8.0	
82.376		35.8	8.9	
85.846		31.5		
Number of lines	(21)	(35)	(33)	(28)
Mean	+ 2.74	—34.50	— 8.54	+ 0.79
Scale Corr.	— .07	+ .05	+ .02	.00
Systematic Corr.	.00	— .22	— .22	— .22
v_s	+ 2.67	—34.67	— 8.74	+ 0.57
Reduction to ☉	—19.40	+17.19	— 8.72	—16.76
Observed V	—16.73 wt. ½	—17.48	—17.46	—16.19

Mean V = —17.00 km.

Mean J. D. 2416989.14
Epoch 1905.38

κ Pavonis R. A. $18^h\ 46^m.6$ Dec. — 67° 21′

Magn. var. Type F5G

Date	1904 May 12.80		1904 June 6.85		1904 June 22.65		1904 Aug. 26.60
Julian day	6613.80		6638.85		6654.65		6719.60
Plate number	317 IV		344 II		352 II		392 III
Photographed by	W.		W.		P.		P.
Measured by	P.	A.	P.	A.	P.	A.	A.
λ							
4246.968					+25.8		
54.505		+18.6		+19.2	24.7	+22.0	+39.2
71.325		26.2		20.0		28.6	35.8
74.935		22.2				26.5	40.1
82.565		24.1		15.4			40.0
94.273		15.9		20.0		25.8	39.8
94.936					25.2		
4303.37					27.0		
06.921		21.4		21.8			47.3
16.962					23.3		
18.867	+24.2	22.0		15.4	27.0	26.2	
21.000		22.7		20.4		28.9	43.7
25.195		20.9	+20.7	20.5	22.9	23.7	40.3
25.939					28.6		
28.101		24.1		15.5			
31.795		25.0	22.2	21.0			
52.012		20.6		14.7		21.5	37.4
52.949		25.1		22.7		17.0	41.7
59.784	25.3						
71.363		26.6		21.3		28.9	
75.119		22.8		18.6			
76.107	20.9	19.7	26.3	18.7	22.1	20.9	41.7
79.396	24.0						
83.720	18.8	22.3	24.3	22.9	23.3	21.8	41.2
87.007		22.2				30.7	41.6
89.413	24.0				24.5		
99.907	26.4						
4400.675		23.0		15.2		19.4	40.8
01.611		19.3		26.0		30.0	45.1
04.927	19.4	22.2	24.2	19.5	25.2	27.4	43.6
07.850		22.5		18.0		25.7	46.0
08.571		27.1				25.4	48.6
17.857	28.5		18.9		27.4		
27.444		24.1		21.8		27.4	42.2
30.785	28.1		21.8				
35.817		24.2					44.0
41.861	29.0						
42.510	23.4	20.2					38.1
43.273		23.6					
43.976	27.5	26.9				25.3	42.0
44.728	20.3		20.2				

κ Pavonis—(Continued)

Date	1904 May 12.80		1904 June 6.85		1904 June 22.65		1904 Aug. 26.60
4447.915	24.7	25.5	20.6	20.7	25.2	19.1	41.0
50.654		27.0		23.6		27.6	42.6
54.958		22.8		20.4		24.2	40.2
59.324		23.6		22.9		31.6	40.8
64.749		25.3		17.3		24.8	44.5
66.727		27.6	21.6	21.3	25.2	28.0	44.5
68.647	23.9		19.8				
71.017			23.4		27.5		
76.211		21.7		23.2		25.4	39.4
4501.445	21.1		20.5				
08.455	21.8		18.9				
Number of lines	(18)	(35)	(14)	(28)	(16)	(27)	(29)
Mean	+23.96	+23.11	+21.67	+19.93	+25.31	+25.33	+41.83
Scale Corr.	— .03	.00	+ .05	+ .06	+ .14	+ .14	+ .28
Systematic Corr.	— .22		— .22		— .22		— .22
v_s	+23.30		+20.64		+25.24		+41.89
Reduction to ☉	+14.85		+ 7.30		+ 1.95		—17.98
Observed V	+38.15		+27.94		+27.19		+23.91

Velocity variable.

τ Sagittarii R. A. 19h 0m7 Dec. — 27° 49′

Magn. 3.4 Type K

Date	1904 May 12.90	1904 June 7.77
Julian day	6613.90	6639.77
Plate number	318 II	346 III
Photographed by	W.	W.
Measured by	P.	P.
λ		
4238.188	+19.4	
46.968	24.6	
68.866	25.1	
4318.867	30.9	+45.1
28.101	25.4	43.0
30.866		49.0
31.795	25.3	
33.925		54.5
40.634	29.4	
43.431		41.8
47.464		47.2
47.705	25.8	50.2
49.150	28.8	
55.294		44.8
59.784	32.5	40.2
69.924	32.7	
76.107	26.8	
79.396	28.2	46.9
90.118	29.9	47.9
4406.810	28.3	47.7
28.711	25.9	
33.414		43.8
35.817	33.2	47.4
42.510	30.9	45.2
47.008		51.8
47.302	27.9	
47.915	28.2	43.2
51.752	26.9	
66.789	32.0	42.4
68.673	29.1	38.2
85.846		42.3
89.911		46.1
Number of lines	(23)	(21)
Mean	+28.14	+45.66
Scale Corr.	.00	+ .08
Systematic Corr.	— .22	— .22
v_s	+27.92	+45.52
Reduction to ⊙	+23.25	+13.22
Observed V	+51.17	+58.74

Velocity variable.

π Sagittarii R. A. 19h 3m8 Dec. —21° 11′

Magn. 3.0 Type F2G

Date	**1903 Sept. 16.58**	**1903 Sept. 29.55**
Julian day	**6374.58**	**6387.55**
Plate number	**5 I**	**19 I**
Photographed by	**P.**	**P.**
Measured by	**A.**	**R.H.C.**
λ		
4250.287	**+16.1**	
50.945	**16.7**	
54.505	**17.4**	**+18.7**
58.370	**18.0**	
60.640		**9.6**
71.325	**13.8**	
74.935	**18.9**	
88.083	**17.9**	
94.273	**13.8**	
99.910		**12.8**
4300.211		**22.9**
13.034		**20.0**
14.357	**16.9**	
15.180		**21.5**
21.000	**19.0**	
25.195		**16.8**
25.939		**14.5**
37.216		**13.9**
40.634	**19.0**	
52.012	**14.9**	
83.720	**16.1**	**17.0**
87.007		**16.7**
95.242	**19.0**	**15.5**
99.907		**22.8**
4404.927	**15.2**	**14.9**
16.985		**19.5**
27.444		**13.7**
43.976		**21.3**
50.654	**18.7**	
81.373	**16.6**	
Number of lines	**(17)**	**(17)**
Mean	**+16.94**	**+17.18**
Scale Corr.	**+ .02**	**— .02**
Systematic Corr.	**— .22**	**— .22**
v_s	**+16.74**	**+16.94**
Reduction to ☉	**—27.81**	**—29.63**
Observed V	**—11.07**	**—12.69**

Mean V = —11.88 km. **Mean J. D. 2416381.06**

Epoch 1903.73

ι Sagittarii R. A. $19^h\ 48^m.4$ Dec. $-42°\ 8'$

Magn. 4.2 Type K

Date	1904 Aug. 25.68
Julian day	6718.68
Plate number	388 II
Photographed by	P.
Measured by	A.
Number of lines	(20)
Mean	+54.29
Scale Corr.	+ .42
Systematic Corr.	— .22
v_s	+54.49
Reduction to ☉	—18.58
Observed V	+35.91

Mean $V = +35.9$ km. Mean J. D. 2416718.68

Epoch 1904.66

NOTE.—As only one observation of this star was secured the results for individual lines are not published. Dr. H. D. Curtis secured two spectrograms at the Chilean station in 1907. His provisional measures of these plates give the following approximate radial velocities:

Date	Velocity	Measured by
1907.49	+35.4	Paddock
1907.50	+34.8	Paddock

δ Pavonis R. A. 19ʰ 58ᵐ9 Dec. — 66° 26′

Magn. 3.6 Type G5K

Date	1904 Apr. 17.88	1904 July 21.81	1904 Sept. 10.61	1905 Mar. 30.88	1905 Apr. 22.89
Julian day	6588.88	6683.81	6734.61	6935.88	6958.89
Plate number	298 IV	364 IV	407 II	670 IV	708 IV
Photographed by	W.	W.	P.	W.	P.
Measured by	P.	P.	P.	P.	P.
λ					
4222.382				—44.4	
33.772					—41.5
38.188					42.4
46.968	—49.3			41.9	38.6
50.287				44.2	43.3
50.962				42.4	39.1
54.505	45.1			44.5	39.0
60.640				44.0	
65.374					35.9
68.866				40.3	
82.565				42.8	40.8
83.169				46.5	
86.627				41.5	38.0
87.605				45.6	41.9
4313.034				44.6	
13.771	47.9			42.5	39.4
18.867	45.5		λ4450 central. System I	45.7	43.4
25.195				43.1	40.8
25.978				44.6	40.4
28.101	48.8	—14.4		41.4	40.3
37.216		16.0		40.1	40.0
40.634	43.2			43.1	39.6
41.530				43.7	
47.705	41.7				
49.150		18.3			42.0
55.294	41.0			38.9	
59.784	39.4	19.0		39.9	42.7
73.119				44.1	39.2
76.107					39.5
79.396	43.5	20.0		46.2	
83.720				41.0	42.3
88.629				39.8	44.7
90.118	47.4			46.6	42.8
99.907	44.7	20.5		41.1	42.5
4404.927	43.1			41.9	41.5
06.810		18.6		42.7	39.2
10.683	50.9				
17.857		18.1			
28.711				43.4	40.2
33.414	46.0				
35.817				41.7	39.1

δ Pavonis—(Continued)

Date	1904 Apr. 17.88	1904 June 21.81	1904 Sept. 10.61	1905 Mar. 30.88	1905 Apr. 22.89
4441.861		16.3	λ4450 central. System I	47.6	42.5
42.510	43.9	16.0		42.2	41.8
43.976				45.5	40.2
47.915		17.2		45.0	43.8
66.789	50.2				43.3
68.673		16.6		48.0	43.9
70.648	43.2				
76.214	42.6			44.3	42.0
82.376		19.7			
4501.445		21.9			
12.906		15.5			
Number of lines	(19)	(15)	(19)	(38)	(36)
Mean	—45.13	—17.87	— 2.91	—43.34	—41.04
Scale Corr.	— .01	— .02	+ .01	— .01	— .04
Systematic Corr.	— .22	— .22	.00	— .22	— .22
v_s	—45.36	—18.11	— 2.90	—43.57	—41.30
Reduction to ⊙	+20.78	— 4.82	—18.76	+21.15	+20.35
Observed V	—24.58	—22.93	—21.66 wt. ½	—22.42	—20.95

Mean V = —22.56 km.

Mean J. D. 2416785.50
Epoch 1904.83

α Pavonis R. A. $20^h\ 17^m7$ Dec. — 57° 3′

Magn. 2.1 Type B3A

Date	1903 Sept. 23.58	1904 May 29.90	1905 Aug. 3.70	1905 Aug. 25.67
Julian day	6381.58	6630.90	7061.70	7083.67
Plate number	17 I	333 II	756 IV	785 III
Photographed by	W.	W.	W.	W.
Measured by	P.	A.	A.	A.
λ				
4267.280	+24.0	—12.4	+7.5	+11.2 wt. 2
85.089			9.3	
4340.634	23.7	4.0	5.2	12.3 wt. 2
47.555				15.5
88.100	25.5	8.0	8.9	12.1 wt. 2
4415.035				11.0
37.718	18.5 wt. ½	10.6	5.6	9.1
47.188		2.6		6.6
48.322		7.7		5.8
69.832				14.2
71.693	25.1	6.0	7.7	11.3 wt. 2
81.375	26.4	5.5	6.2	11.7 wt. 2
Number of lines	(6)	(8)	(7)	(11)
Mean	+24.35	— 7.10	+7.20	+11.21
Scale Corr.	— .04	— .02	.00	— .03
Systematic Corr.	— .22	— .22	— .22	— .22
v_s	+24.09	— 7.34	+6.98	+10.96
Reduction to ☉	—22.46	+16.52	—7.78	—15.50
Observed V	+ 1.63	+ 9 18	—0.80	— 4.54

Velocity variable. Velocity of system +2.0 km.

For elements of orbit see Addendum.

α Indi R. A. $20^h\ 30^m5$ Dec. — 47° 38′

Magn. 3.2 Type K

Date	1904 May 18.84		1904 June 24.90	1905 May 3.87	1905 Aug. 7.71
Julian day	6619.84		6656.90	6969.87	7065.71
Plate number	328 IV		359 IV	725 IV	764 III
Photographed by	W.		W.	W.	P.
Measured by	W.	P.	W.	P.	P.
λ					
4233.772			—10.8		
38.980				—22.9	+7.8
46.968		—30.6	11.0	26.9	6.5
50.287		30.8	10.6	25.4	5.9
50.962		26.5		22.0	6.8
54.505			9.5	28.3	6.2
74.935		22.8		26.1	7.1
78.390				29.0	5.8
82.565	—19.3		6.8		9.8
83.169	27.0		13.4		
84.382		27.0			
86.627			10.8		
87.605				27.4	
94.273		24.3		30.6	3.7
4313.034		29.8			2.1
13.771	25.7		14.2	28.7	
18.867	24.0	23.3	14.6	26.1	8.7
25.195	24.6	24.3	8.7	25.5	5.6
25.978					6.0
28.101	24.4	20.6	11.9	24.8	2.5
37.216	25.3	21.5	9.7	27.8	3.0
37.725			14.0		
38.084			13.7		
40.634	20.0	19.0	12.8	26.1	7.3
41.530			10.9		
47.464			14.6		
49.150			11.3		
52.972		25.5		27.8	5.3
55.294			11.9		
59.784	21.7		11.8		
66.061			9.1		
71.363		19.9		27.2	6.9
75.119		23.9		21.3	
76.107	24.4	23.4	10.6	23.6	6.4
79.396	27.4	28.6	12.7	26.4	3.0
83.720					6.8
88.629			16.0		
90.118			10.8	26.2	3.8
91.152					7.6
95.270		23.9		27.1	6.1
99.907	26.4		11.1	29.1	6.0

a Indi—(Continued)

Date	1904 May 18.84		1904 June 24.90	1905 May 3.87	1905 Aug. 7.71
4404.927	22.4	25.8	10.8		7.0
06.810			12.3	25.7	8.4
07.850				26.1	4.9
15.312		23.2		29.4	6.1
18.542				28.4	
25.608			9.4		
30.785			12.7	28.9	
35.817	25.4				7.1
41.861	18.7	22.5	7.3	25.4	5.7
42.510	25.8	24.5	12.2	25.0	7.5
43.976				27.0	
47.915	22.4	24.4	13.7	23.2	5.1
66.789		23.7		27.4	
68.673		30.8		23.3	6.1
69.545	19.8				
76.211		24.9		26.6	6.3
82.376		28.0		26.6	6.9
Number of lines	(18)	(27)	(33)	(36)	(36)
Mean	—23.59	—24.94	—11.57	—26.37	+6.05
Scale Corr.	— .03	— .02	— .02	+ .07	— .01
Systematic Corr.	— .22		— .22	— .22	— .22
v_s	—24.51		—11.81	—26.52	+5.82
Reduction to ⊙	+22.73		+10.61	+25.37	—7.96
Observed V	— 1.78		— 1.20	— 1.15	—2.14

Mean V = —1.57 km.

Mean J. D. 2416828.08
Epoch 1904.95

β Indi R. A. $20^h\ 47^m0$ Dec. — 58° 50′

Magn. 3.7 Type K

Date	1904 May 29.81	1904 Oct. 17.61	1905 July 21.81	1905 Aug. 22.74
Julian day	6630.81	6771.61	7048.81	7080.74
Plate number	332 IV	438 II	748 III	777 IV
Photographed by	W.	P.	W.	W.
Measured by	P.	W.	P.	A.
λ				
4238.980			—3.8	+ 5.6
39.965				5.2
45.435				6.4
46.160				5.7
46.968			7.1	6.5
50.287			4.3	
50.962			5.7	5.4
58.50				4.6
68.866				3.6
71.325				6.4
74.935			3.0	6.4
78.390			1.6	7.3
82.565			1.2	
87.605			4.3	
92.304				5.4
93.239				2.9
94.273		λ4450 central. System II	8.4	
4306.921				4.3
13.034			4.0	
13.771				5.8
14.357				6.1
18.867	—25.8		1.8	7.1
21.000	27.6			
25.195			4.4	4.9
25.978			2.9	
28.101	23.4		4.6	5.8
31.795	22.0		6.5	6.0
34.101				4.8
35.000				2.3
37.216	21.5		5.2	3.6
39.723				6.4
40.634	26.1			7.1
44.625				6.5
46.725			2.4	
49.150				3.8
52.012				3.1
52.972	25.0		5.8	4.8
59.784				6.4
69.924	23.2			7.4
71.363	20.7		2.4	
76.107	22.6		3.6	5.4

β Indi—(Continued)

Date	1904 May 29.81	1904 Oct. 17.61	1905 July 21.81	1905 Aug. 22.74
4379.396	22.6		5.1	
90.118			4.0	
91.152			3.5	6.8
95.270	20.7		4.8	6.3
99.907	29.1		3.9	
4404.927	25.0			
06.810	25.2		5.3	3.3
07.850	24.2	λ4450 control. System II	4.1	7.8
15.312	21.7			
27.444				4.8
33.414				6.2
34.060				3.0
35.817			4.4	6.0
41.861	27.8		5.9	5.7
42.510	18.6		1.6	4.5
47.915	26.3		4.7	4.1
59.324				8.1
60.486				4.6
66.789	21.0		2.7	4.2
68.673	24.0		2.7	8.8
76.214	24.4		4.0	
82.376			5.0	
Number of lines	(23)	(32)	(35)	(47)
Mean	—23.85	+16.76	—4.13	+ 5.47
Scale Corr.	— .05	+ .02	.00	— .01
Systematic Corr.	— .22	.00	— .22	— .22
r_s	—24.12	+16.78	—4.35	+ 5.24
Reduction to ☉	+17.12	—23.33	—1.14	—12.77
Observed V	— 7.00	— 6.55 wt. ½	—5.49	— 7.53

Mean V = —6.65 km.

Mean J. D. 2416898.90
Epoch 1905.14

γ Pavonis R. A. $21^h\ 18^m2$ Dec. — 65° 49′

Magn. 4.3 Type F8G

Date	1904 Sept. 21.67	1904 Oct. 14.64	1905 Aug. 4.77	1905 Aug. 29.75
Julian day	6745.67	6768.64	7062.77	7087.75
Plate number	423 III	434 II	758 III	788 III
Photographed by	W.	W.	W.	W.
Measured by	W.	W.	W.	P.
λ	λ4450 central. System II	λ4450 central. System II		
4246.968			—24.0	—17.9
50.287			18.0	19.8
50.945			26.8	16.5
54.505				17.1
60.640			23.8	14.7
74.935				14.2
82.565			29.5	13.6
83.169			21.9	17.1
94.273				15.9
4300.211			26.9	
13.034				18.0
25.195				19.0
25.939			21.8	15.0
37.216			19.6	
40.634			24.0	17.7
52.949				17.8
59.784			27.2	
69.924			27.1	14.9
76.107			22.8	
83.720			20.4	15.5
95.242				17.0
99.907				17.8
4404.927			22.8	12.2
15.312				17.7
27.444			22.7	
35.817			21.0	14.3
47.915				15.4
66.727				17.5
68.647				18.7
76.214				17.7
82.376				18.5
Number of lines	(19)	(33)	(17)	(26)
Mean	—12.28	—11.73	—23.55	—16.60
Scale Corr.	+ .26	.00	+ .03	+ .02
Systematic Corr.	.00	.00	— .22	— .22
v_s	—12.02	—11.73	—23.74	—16.80
Reduction to ⊙	—18.01	—20.40	— 5.36	—12.95
Observed V	—30.03 wt. ½	—32.13 wt. ½	—29.10	—29.75

Mean V = —29.98 km. Mean J. D. 2416969.22

Epoch 1905.33

ν Octantis R. A. 21ʰ 30ᵐ4 Dec. — 77° 50′

Magn. 3.7 Type K

Date	1904 June 8.82	1904 Oct. 13.64	1905 Aug. 7.81	1905 Sept. 6.71
Julian day	6640.82	6767.64	7065.81	7095.71
Plate number	349 III	432 II	765 IV	796 III
Photographed by	W.	W.	P.	W.
Measured by	P.	W.	P.	W.
λ				
4238.980			+39.6	
46.968	+14.8		43.6	
50.287	17.3		40.4	+49.9
50.962	17.5		42.9	50.5
54.505	15.3		42.1	
57.815				44.0
68.866	21.5			
74.935			43.7	51.4
78.390			45.5	50.2
82.565	16.9			56.4
83.169				48.1
91.630				53.4
94.273			43.6	
4300.211				50.7
13.034			40.5	
13.771	16.8	λ4450 central. System II		46.7
18.867	20.2		43.1	48.2
25.195			45.9	49.1
25.978				52.8
28.101	18.5		44.5	45.5
31.795	18.3			48.1
37.216	22.0		43.6	51.8
40.634	21.9		44.4	46.9
41.530	15.0			
47.705	23.9			
52.972			44.4	47.2
59.784	23.1			49.5
69.924	22.9			48.0
71.363			45.0	
75.119				49.4
76.107	21.4		44.7	47.5
79.396	22.3			
88.629	18.6			
90.118	23.1		41.8	51.1
91.152			44.9	51.8
95.270			45.9	
99.907	18.1		42.8	51.0
4404.927				49.3
06.810	24.0		42.5	48.6
07.850			40.0	50.3
15.312			43.5	

ν Octantis—(Continued)

Date	1904 June 8.82	1904 Oct. 13.64	1905 Aug. 7.81	1905 Sept. 6.71
4427.444				49.1
28.711	21.7	λ4450 central. System II		
33.414	25.6			
35.817			47.5	46.7
41.861	20.5		44.3	47.1
42.510	23.1		44.7	50.1
47.915	20.7		44.1	48.7
66.789	21.0		42.9	
68.673			42.9	
76.211			47.1	
82.376			44.2	
4501.445	20.8			
Number of lines	(29)	(26)	(32)	(33)
Mean	+20.24	+44.41	+43.64	+49.37
Scale Corr.	+ .04	+ .06	— .10	— .06
Systematic Corr.	— .22	.00	— .22	— .22
v_s	+20.06	+44.47	+43.32	+49.09
Reduction to ⊙	+ 8.01	—15.95	— 7.22	—13.17
Observed *V*	+28.07	+28.52 wt. ½	+36.10	+35.92

Velocity variable.

α Tucanae R. A. 22^h 11^{m}7 Dec. — 60° 45′

Magn. 2.9 Type K2M

Date	1903 Sept. 20.58	1904 Sept. 10.70	1904 Oct. 18.61	1905 July 16.76	1905 July 22.89	1905 Sept. 2.72
Julian day	6378.58	6734.70	6772.61	7043.76	7049.89	7091.72
Plate number	9 I	408 III	441 II	741 III	751 IV	794 III
Photographed by	P.	P.	P.	W.	W.	W.
Measured by	P.	P.	P.	A.	A.	A.
λ						
4233.772	+55.1					
38.980						+55.1
39.965						56.1
45.435				+36.2		52.0
46.160				32.7	+38.0	54.0
46.968	54.3			35.4		52.2
47.584					36.6	53.5
50.287				35.6		53.1
50.962				34.1		
57.815	53.8				37.4	
61.376	57.3					
63.290	56.7					
65.374	52.0					49.7
68.866	53.6			37.3	37.0	51.9
78.390					38.1	
86.627	53.4					
87.605	55.1				35.9	52.2
93.272						52.1
4313.771	54.0					
14.357				35.0		
18.867	53.8	λ4450 central. System 1	λ4450 central. System 1		37.6	52.5
21.898					35.6	
28.101	54.3			35.9	37.3	52.9
30.189	56.6					
34.101				36.0		54.2
35.000				35.1	37.7	
37.216	53.3			35.4	37.4	
39.723				35.2	37.7	52.5
40.634				34.7		53.7
43.402	51.8					53.8
44.625				35.5	38.9	52.8
47.464	52.9					
49.150	54.2			32.8		
52.012				32.4		52.0
52.990				35.0	38.4	53.0
55.294	52.3					
59.784	54.9			36.3	40.1	54.7
69.924					39.1	52.0
71.363				34.4		51.3
75.119	52.2			34.6		54.6
76.107	55.0			35.1	36.8	52.8

α Tucanae—(Continued)

Date	1903 Sept. 20.58	1904 Sept. 10.70	1904 Oct. 18.61	1905 July 16.76	1905 July 22.89	1905 Sept. 2.72
4379.396	54.1			34.5	36.5	54.1
88.629	56.8					
89.413	55.5					
90.143	54.5			35.1	38.3	53.2
91.152				33.7	37.3	54.0
95.298						51.7
4400.675					36.0	
01.611				36.1	37.8	53.9
06.810	56.6			34.5	34.5	53.2
07.850				35.7	38.4	55.9
08.571				36.3		
17.857	58.7					
25.608	55.4	λ4450 central. System I	λ4450 central. System I			
27.444				35.0	37.4	53.2
28.711	55.1				36.4	
33.414					39.2	
34.060					37.6	52.7
35.244					36.5	
35.817	53.7				34.4	
38.006	49.9					
41.861	54.5					51.0
42.510	54.3			35.5	40.0	52 3
47.915	51.1			34.9	36.5	49.8
51.752	53.4					
55.485	54.6					
57.656						52.4
59.324				35 3		55.2
66.789	54.6			34 5	39.5	52.3
68.745				36.0	39.2	50.3
76.185	53.7					
82.376	53.0					
4505.003	55.5					
Number of lines	(40)	(34)	(47)	(34)	(34)	(41)
Mean	+54.29	+53.80	+60.68	+35.05	+37.50	+52.92
Scale Corr.	+ .14	— .19	— .01	— .04	— .08	— .08
Systematic Corr.	— .22	.00	.00	— .22	— .22	— .22
v_s	+54.21	+53.61	+60.67	+34 79	+37.20	+52.62
Reduction to ☉	—15.88	—13.57	—20.60	+ 5.07	+ 2.82	—11.19
Observed V	+38.33	+40.04 wt. ½	+40.07 wt. ½	+39.86	+40.02	+41.43

Mean V = +39.94 km.

Mean J. D. 2416863.46
Epoch 1905.05

δ^1 *Gruis* R. A. 22^h 23^{m}3 Dec. — 44° 0′

Magn. 4.0 Type G5K

Date	1904 Oct. 12.66	1904 Oct. 21.64	1905 Aug. 5.84	1905 Nov. 10.58	1905 Nov. 18.58
Julian day	6766.66	6775.64	7063.84	7160.58	7168.58
Plate number	429 II	444 II	761 II	818 II	825 II
Photographed by	P.	P.	W.	W.	W.
Measured by	W.	A.	A.	A.	P.
λ	λ4450 central. System II	λ4450 central. System II			
4238.980				+32.8	
45.435			+4.0	31.4	
46.968			0.5	32.2	+32.9
47.584				31.9	
50.287			4.4	31.2	31.3
50.962			2.1	31.0	33.1
54.505			3.7	30.9	30.7
58.50					31.9
68.866			0.8		
74.935			2.6	33.1	33.1
78.390					32.2
92.304				31.2	
94.273			1.5	30.1	30.4
4306.921			3.1	30.4	
13.034					30.1
14.357			4.3	32.1	
18.867			4.0	31.1	34.6
21.898			6.3	30.8	
25.195			5.4	31.8	36.1
25.978				32.3	34.7
28.101			1.4	31.0	32.7
31.795			3.4		
34.101			1.1	30.4	
37.216			5.9	29.2	31.0
39.723			4.1	29.5	
40.634			3.8	35.1	34.7
44.625			2.5	28.6	
52.012			2.2	31.4	
52.949			2.4	30.7	32.4
59.784			4.0	31.8	
69.924			2.4		
71.363			2.8	30.7	
75.119			3.4		
76.107			3.7		26.7
79.396					30.2
90.118			6.5	28.3	
91.152				32.0	
95.270			3.3	29.6	32.8
4400.675			3.5		
01.611			1.5	31.7	
04.927				32.1	

δ^1 *Gruis*—(Continued)

Date	1904 Oct. 12.66	1904 Oct. 21.64	1905 Aug. 5.84	1905 Nov. 10.58	1905 Nov. 18.58
4406.810			2.3	30.8	
07.850				33.5	32.4
15.312	λ4450 central. System II	λ4450 central. System II			37.0
27.444			3.6	30.6	
41.861					31.3
42.510			3.5	35.1	28.8
47.915			4.9	31.2	31.8
59.324			5.6	31.4	
66.727			2.6	34.5	36.6
68.673			1.7	31.7	34.5
76.214					30.0
Number of lines	(25)	(31)	(38)	(39)	(27)
Mean	+27.42	+29.83	+3.28	+31.42	+32.37
Scale Corr.	+ .04	.00	— .01	— .03	— .03
Systematic Corr.	.00	.00	— .22	— .22	— .22
v_s	+27.46	+29.83	+3.05	+31.17	+32.12
Reduction to ⊙	—22.22	—24.00	+2.73	—25.80	—25.74
Observed V	+ 5.24 wt. ½	+ 5.83 wt. ½	+5.78	+ 5.37	+ 6.38

Mean V = +5.76 km.

Mean J. D. 2417041.10
Epoch 1905.53

β Gruis R. A. 22h 36m7 Dec. — 47° 24′

Magn. 2.2 Type Mb

Date	1904 July 22.72[1]	1904 Sept. 26.67	1905 Aug. 5.71[2]		1905 Aug. 12.71	1905 Oct. 26.64		1905 Nov. 24.56
Julian day	6684.72	6750.67	7063.71		7070.71	7145.64		7174.56
Plate number	367 III	424 II	760 IV		770 II	804 III		836 II
Photographed by	W.	P.	W.		W.	W.		W.
Measured by	P.	A.	W.	P.	A.	W.	P.	A.
λ								
4238.980				—0.3				
39.965								+28.1
45.435					+1.2			26.0
46.160								25.6
46.968	—·9.2		+1.3	0.0	+0.6		+22.6	26.5
47.584					+0.3			24.8
50.287	13.8		—0.6	—1.3	+2.5	+23.2	24.3	24.6
50.962	3.5		—4.2	—3.0	—0.8			20.1
54.505			—5.1					
58.50				—1.0	+0.8		24.6	23.2
65.320			—1.0		+3.9	21.6		
68.866								22.0
71.325					+3.3			
74.935			+2.2					
83.169						22.6	27.6	
87.605		λ4450 central. System II	+1.3					
91.630			+0.7					
94.273	10.5			0.0			23.8	
4300.732			+0.3			18.4		
13.034								25.6
18.867			—1.2	—1.9	+2.9	25.6	27.0	24.9
21.898					—1.0			23.2
25.195			+0.4	+1.9	+4.2	25.6		26.6
25.978			—3.1	—2.1		19.1		
28.101	6.1				+2.8			
30.189					+4.2			26.9
31.795	3.6		+1.8			26.9		25.1
32.921					+3.0			
34.101								27.4
35.000					+2.0			25.7
37.216	9.4		—2.5	—0.4	+2.7	20.0	21.5	24.4
37.725			—1.1			25.0		
39.723					+2.2			24.5
40.634			+1.4	—2.0		26.1	22.9	
44.625					+3.9			25.7
46.725								23.3
47.464			—3.5		+0.9			27.6
51.973								23.7
53.008					+2.1		25.8	24.4
55.294	14.5							

1 Spectrogram underexposed, comparison poor.

2 Part of comparison spectrum was accidentally omitted in securing this spectrogram.

β Gruis—(Continued)

Date	1904 July 22.72	1904 Sept. 26.67	1905 Aug. 5.71		1905 Aug. 12.71	1905 Oct. 26.64		1905 Nov. 24.56
4359.784			+0.7		+5.5	28.3		27.8
69.924	7.1			−0.4				25.9
71.363	8.5			−0.6			24.7	
75.119	6.4			0.0	+1.5	25.1		
76.107	5.1		0.0	+0.6	+2.2	23.9	23.7	24.7
79.396	10.0		−0.5		+2.6	22.9	22.9	23.9
79.854				+2.1				
83.720	15.7		−1.9	−1.7	+2 6	21.2		24.0
89.413					+2.9			26.1
90.168	6.8			−1.0	+1.8	24.7	24 6	24 2
91.152	11.0				+0.7	21.3	20.8	22.8
95.298		λ4450 central. System II		+2.0	+2.2	23 6	21.6	25.5
4400.675					+3.1			25.9
04.927				+2.5		22.1		
06.810	8.4		−0.4	+0.8	+1.2	24.5	24.0	24 7
07.850	11.6		−3.5	−4.5	+1.2	21.4	18.5	23.0
15.312					−1.0			
16.752								24.3
27.444			−0.8		+0.4	24.3		25.6
28.711					−1.0	21.1		24.0
30.785	14.3							
34.060					−0.8			
35.244					+0.4			25.9
35.817			−1.6	−0.2		21.4		26.9
41.861	13.2		−4.0	−1.4	+1.0	22.3	23.6	25.0
42.510	8 4		+2.4	+0.8	0.0	23.6	23.8	27.8
47.915	9.1			−1.8	−1.8		21.9	24.4
59.324					+1.4			25.2
60.486								24.2
66 789	7.8			−1.4	+0.6		20.9	22.2
68.745	10 0			−4.6			19.6	23.6
76.214	11.2							
82.376	13.6			+0.1			20.7	
Number of lines	(26)	(42)	(27)	(29)	(42)	(27)	(23)	(48)
Mean	− 9.57	+17.31	−0.83	−0.65	+1.63	+23.18	+23.10	+24.95
Scale Corr.	− .03	− .37	.00	.00	.00	− .06	− .05	− .08
Systematic Corr.	− .22	.00	−. 22		− .22	− .22		− .22
v_s	− 9.82	+16.94	−0.96		+1.41	+22.86		+24.65
Reduction to ⊙	+ 8.58	−16.78	+4.07		+0.35	−23.49		−24.26
Observed *V*	− 1 24[1]	+ 0.16 wt. ½	+3.11[2]		+1.76	− 0.63		+ 0.39

Mean *V* = +0.63 km.

Mean J. D. 2417002.67
Epoch 1905.42

The velocity of this star is strongly suspected of variabilty. Plates taken by Dr. Curtis for the purpose of confirming the variation give the following velocities:

Date			Velocity	Measured by	Dispersion used
1906,	Oct.	16.643	− 0.3 km.	Pk.	3 prisms
		26.664	− 1.5 km.	Pk.	3 prisms
1907,	June	3.910	+ 1.2 km.	Pk.	3 prisms
		19.758	+ 1.4 km.	Pk.	3 prisms
		21.783	+ 2.1 km.	Pk.	3 prisms
	Oct.	12.588	+ 0.3 km.	Pk.	3 prisms
		13.658	+ 1.4 km.	Pk.	3 prisms
1908,	Nov.	13.547	+ 3.0 km.	Pk.	2 prisms
	Nov.	13.547	+ 4 2 km.	H D.C.	2 prisms
	Nov.	15.526	+ 4 3 km.	Pk.	2 prisms
	Nov.	15.526	+ 3.3 km.	H.D.C.	2 prisms
	Nov.	20.536	+ 3.4 km.	Pk.	2 prisms
	Nov.	20.536	+ 4.2 km.	H.D.C.	2 prisms

δ Piscis Australis R. A. 22h 50m4 Dec. — 33° 4′

Magn. 4.3 Type K

Date	1904 Oct. 16.68	1904 Oct. 25.65	1905 Aug. 21.82	1905 Nov. 4.63
Julian day	6770.68	6779.65	7079.82	7154.63
Plate number	436 II	445 II	775 III	811 III
Photographed by	W.	P.	W.	W.
Measured by	W.	W.	W.	W.
λ				
4246.968			—13.3	+14.9
50.287			13.4	15.6
50.962			14.0	14.0
54.505			13.1	13.4
74.935			12.2	13.7
78.390				12.2
82.565			10.6	
83.169			14.3	
4313.771			10.4	14.9
18.867			13.4	15.1
25.195	λ4450 central. System II	λ4450 central. System II	11.9	15.4
25.978			10.9	15.2
28.101			14.5	14.1
31.795				15.2
37.216			11.4	15.0
40.634			11.5	12.5
41.530			12.2	
59.784			11.7	14.7
75.119				12.7
76.107			10.8	10.5
79.396			12.1	13.9
83.720			11.0	14.0
91.152			9.5	16.4
95.270			11.6	13.3
4404.927			10.5	14.7
06.810			12.1	15.2
07.850			12.9	15.6
27.444			12.8	12.0
35.817				13.7
42.510			13.4	15.5
Number of lines	(34)	(27)	(26)	(27)
Mean	+10.25	+12.67	—12.13	+14.20
Scale Corr.	.00	.00	.00	— .03
Systematic Corr.	.00	.00	— .22	— .22
v_s	+10.25	+12.67	—12.35	+13.95
Reduction to ⊙	—22.19	—24.49	+ 0.61	—26.35
Observed *V*	—11.94 wt. ½	—11.82 wt. ½	—11.74	—12.40

Mean *V* = —12.01 km. Mean J. D. 2417003.20

Epoch 1905.43

ζ Gruis — R. A. $22^h\ 55^m.0$ Dec. — 53° 17′

Magn. 4.2 — Type G5K

Date	1904 Sept. 14.76	1904 Oct. 28.64	1904 Nov. 8.62	1905 Aug. 30.77	1905 Sept. 26.60
Julian day	6738.76	6782.64	6793.62	7088.77	7115.60
Plate number	421 III	449 II	459 II	791 IV	799 II
Photographed by	W.	W.	P.	W.	W.
Measured by	W.	W.	W.	P.	A.
λ					
4238.980				−0.9	
45.435					+ 6.2
46.968				−1.6	8.2
47.584					6.1
50.287				−2.2	
50.962				−1.1	5.9
54.505				−0.8	6.2
74.935				−0.1	9.5
84.382				−3.3	
87.605				−3.2	
92.304					7.1
94.273				−3.0	7.3
4306.921					7.7
13.034				−5.2	
14.357					9.2
18.867				−1.8	7.1
25.195	λ4450 central. System II	λ4450 central. System II	λ4450 central. System II	−0.4	6.0
25.978				+0.8	5.3
28.101				−0.5	
37.216				−2.0	6.6
40.634				0.0	7.5
44.625					5.8
52.012					8.2
52.949				+1.6	8.9
59.784					7.7
69.924				+0.7	7.8
71.363				+2.4	8.6
76.107				−3.0	6.5
79.396				−3.0	
90.118				−2.5	
95.270				−1.0	
99.907				−2.1	
4400.675					5.8
01.611					8.3
04.927				−3.1	
06.810				−0.4	8.4
07.850				−3.9	7.2
08.571					7.8
15.312				−2.6	4.1
27.444					7.4
28.711					10.4

ζ Gruis—(Continued)

Date	1904 Sept. 14.76	1904 Oct. 28.64	1904 Nov. 8.62	1905 Aug. 30.77	1905 Sept. 26.60
4434.060					7.6
35.214					7.0
35.817	λ4450 central. System II	λ4450 central. System II	λ4450 central. System II	0.0	
41.861				—2.2	
42.510				—2.0	9.4
43.976				0.0	
47.915				—1.0	
66.789				+0.4	
68.673				—2.7	
76.214				—0.2	
82.376				—0.6	
Number of lines	(18)	(26)	(19)	(37)	(33)
Mean	+ 3.23	+17.43	+21.10	—1.36	+ 7.36
Scale Corr.	— .08	— .01	+ .02	.00	.00
Systematic Corr.	.00	.00	.00	— .22	— .22
r_s	+ 3.15	+17.42	+21.12	—1.58	+ 7.14
Reduction to ☉	—11.89	—21.69	—22.45	—6.63	—14.28
Observed V	— 8.74 wt. ½	— 4.27 wt. ½	— 1.33 wt. ½	—8.21	— 7.14

Velocity variable.

The following measurements by Mr. Paddock amply confirm the variation indicated by the above observations:

Date			Velocity	Measured by
1907,	July	20.90	— 4.9 km.	Pk.
	Oct.	3.76	— 4.3 km.	Pk.
	Nov.	14.56	+ 1.7 km.	Pk.

ι Gruis — R. A. 23ʰ 4ᵐ7 Dec. — 45° 47′

Magn. 4.1 — Type K

Date	1903 Nov. 9.65	1904 Sept. 12.76	1904 Oct. 27.67	1905 Nov. 1.66	1905 Nov. 13.59	1905 Nov. 19.61
Julian day	6428.65	6736.76	6781.67	7151.66	7163.59	7169.61
Plate number	38 I	416 III	447 II	809 II	821 II	827 IV
Photographed by	P.	W.	W.	W.	W.	W.
Measured by	A.	W.	W.	A.	P.	A.
λ						•
4239.980				+19.7		
39.965				19.6		+20.2
45.435				18.8		19.8
46.160	+14.8					20.7
46.968				20.5	+24.0	21.7
47.584				19.1		21.0
50.287	14.5			19.0	19.6	20.7
50.962				18.6	21.6	20.0
54.505				19.8		19.8
68.866	11.9			20.7		22.0
71.325						18.3
74.935				19.2	22.6	20.4
78.390						21.3
82.565						21.0
84.382					15.8	
87.605	15.4					18.6
92.304						21.0
93.239	15.0			20.7		21.7
94.273	13.1			19.1	20.1	
4306.921		λ4450 central. System II	λ4450 central. System II	19.2		19.6
13.034				18.0		
13.771						21.0
14.357	17.3			19.9		20.4
18.867	11.7			19.8	25.2	19.1
21.898				23.4		
25.195				19.8		
25.978				17.0		
28.101				20.2	20.4	20.8
31.795				17.4		22.5
34.101				19.5		20.7
37.216	14.6			19.9	14.4	19.3
39.723	14.2			20.0		18.4
40.634				20.3		22.5
43.402						20.9
44.625				17.8		20.5
49.150						23.4
52.012				19.3		20.2
52.972	14.6			18.8	20.8	20.1
55.294						18.5
59.784	15.5			19.3		22.2
69.924					21.9	21.5

ι Gruis—(Continued)

Date	1903 Nov. 9.65	1904 Sept. 12.76	1904 Oct. 27.67	1905 Nov. 1.66	1905 Nov. 13.59	1905 Nov. 19.61
4371.363	11.8			19.1	24.0	
76.107	12.1			17.5	19.3	20.9
79.396	12.9					22.1
90.118				18.1		20.6
91.152	16.8					20.3
95.270				19.5	23.8	20.9
99.907					15.6	21.6
4400.675				17.4		21.1
01.611	18.4			17.2		21.9
06.810	13.9				22.4	18.3
07.850	19.0	λ4450 central. System II	λ4450 central. System II		16.4	19.3
08.571	13.6			16.4		20.7
11.240	17.5					
17.857					26.6	
18.542					23.4	21.7
27.444	15.0			18.7		20.6
28.711	15.8					
33.414	14.1					23.8
35.214				19.1		22.4
35.817						20.6
41.861	11.9				13.8	20.6
42.510	14.5			18.7	19.5	22.7
47.915				16.2	22.8	21.7
57.656						21.7
59.324	14.4			19.7		23.2
60.486						22.8
66.789				15.9	17.6	21.2
68.673				21.0	18.3	23.1
76.214	12.1				19.8	
82.376	11.0				23.1	
Number of lines	(29)	(38)	(29)	(43)	(26)	(58)
Mean	+14.39	+7.61	+17.00	+19.04	+20.49	+20.92
Scale Corr.	.00	— .17	.00	— .03	.00	— .04
Systematic Corr.	— .22	.00	.00	— .22	— .22	— .22
v_s	+14.17	+7.44	+17.00	+18.79	+20.27	+20.66
Reduction to ⊙	—24.07	—9.66	—22.59	—23.30	—24.29	—24.48
Observed *V*	— 9.90	—2.22 wt. ½	— 5.59 wt. ½	+ 4.51	— 4.02	— 3.82

Velocity variable.

Further spectrograms of this star were kindly secured by Dr. Curtis.

	Date		Velocity	Measured by
1907.	June	23.827	—18.8 km.	H.D.C.
	July	27.875	+ 7.5 km.	H.D.C.
	Oct.	2.694	+ 3.1 km.	Pk.
	Nov.	23.574	+ 0.6 km.	H.D.C.

Mars

Date	1905 Jan. 31.85	1905 Mar. 11.89	1905 Mar. 29.75	1905 June 21.62	1905 July 23.58	1905 Aug. 24.52
Julian day	6877.85	6916.89	6934.75	7018.62	7050.58	7082.52
Plate number	574 IV	629 IV	665 III	738 III	753 III	781 II
Photographed by	W.	W.	W.	P.	W.	W.
Measured by	P.	P.	W.	P.	P.	W.
λ						
4222.382	—20.8		—15.8			
31.183	18.0		13.4			
33.772	20.3		15.2			+5.0
38.188	19.5	—21.5	13.6		+5.5	
46.968	18.4	14.7	14.0	+6.3	7.9	11.3
50.287	19.9	18.3	13.0	5.8	6.8	7.1
50.962	17.9	17.3		6.9	6.8	
54.505	18.8	16.4	16.9	6.0	6.7	8.4
57.815		18.2				
60.640				8.7		
67.543		19.8				
68.866	13.6			5.7		
74.935					9.5	
82.127	17.3					
82.565		16.9	13.4	5.3	8.5	8.0
83.169	18.8	17.1	17.9		5.8	
86.627	15.6		13.6	9.6		10.0
87.605		18.1	16.7	5.7		
89.525			14.9			
4303.337			15.6			
13.034	15.1				7.8	
13.771		18.6	14.6	6.8	3.8	11.1
18.867	18.2	20.6	15.9	4.4	6.2	6.2
25.195	18.6	18.2		5.6	6.7	7.8
25.978	17.3	17.7	14.1		7.4	7.7
28.101	20.1	19.7	14.2		6.0	
37.216	17.8	18.9	16.9	4.6	7.5	10.3
37.725		16.9	13.4			
38.084		15.6	14.1			9.1
40.634	16.6	15.9	14.5	5.9	9.0	6.3
41.530				10.2		
43.402				4.7		
52.949					7.8	
55.294			14.8			
59.784	19.3	18.4	16.0	5.9		7.2
69.924	18.9	19.1	13.1			7.9
75.119		18.5		3.6		
76.107	19.1	17.2	12.7	5.6	7.1	6.2
79.396	20.2	14.6	15.6	6.0	5.6	
83.720		15.9	13.4	8.7	9.8	7.6
88.629	22.1	19.3		3.3		
90.118	21.8	13.8		9.5		

Mars—(Continued)

Date	1905 Jan. 31.85	1905 Mar. 11.89	1905 Mar. 29.75	1905 June 21.62	1905 July 23.58	1905 Aug. 24.52
4391.152					6.9	
95.270					9.2	
99.907	20.1	15.5	17.8	7.9	4.8	6.9
4404.927	19.4	16.3	12.4	8.1	9.7	8.7
06.810	19.7	15.4	12.7	7.6	7.6	
07.850					8.6	
10.683		15.9				
15.722						13.2
17.857	18.7	14.9	13.8	7.3		
25.608	15.7	15.3		7.2		
30.785	17.2	19.4	13.4	4 6		
35.817	15.0	14.8	14.8	9 9	11.7	12.1
38.006	23.0					
41.861	19.2	16.8		6.4	10.4	
42.510	16.8	16.2	15.2	5.3	8.1	10.6
43.976	20.2	18.4	14.3	7.5	8.5	5.7
47.915	17.3	18.1	16.7	3.3	7.8	7.6
51.752	17.1	15.8		3.5		
66.727	18.2		15.5	5.0	5.9	
68.647	19.1	18.0	14.3	4.6	6.7	
76.214	18.5	16.9	13.5	5.1	10.6	
Number of lines	(41)	(42)	(39)	(38)	(34)	(24)
Mean	—18.56	—17.26	—14.66	+6.27	+7.61	+8.42
Scale Corr.	+ .01	.00	— .01	— .01	— .02	— .01
Systematic Corr.	— .22	— .22	— .22	— .22	— .22	— .22
Observed V	—18.77	—17.48	—14.89	+6.04	+7.37	+8.19
Computed V	—18.97	—17.21	—15.14	+5.86	+7.98	+8.48
$(O-C)$*	+ 0.20	— 0.27	+ 0.25	+0.18	—0.61	—0.29

Mean $O - C = -.09$ km.

* In any consideration of the significance of these quantities it should be borne in mind that the *systematic corrections* were so chosen as to make the mean of all the planet and Moon and sky checks zero.

Venus

Date	1903 Nov. 22.86	1903 Dec. 12.86		1903 Dec. 19.86		1904 Jan. 5.89	1904 Mar. 1.90	1904 Mar. 14.93
Julian day	6441.86	6461.86		6468.86		6485.89	6541.90	6554.93
Plate number	59 III	76 II		90 III		116 IV	207 IV	245 II
Photographed by	W.	W.		P.		W.	W.	W.
Measured by	W.	W.	W.	P.	R.H.C.	P.	R.H.C.	P.
λ								
4187.204								+4.6
91.595								9.5
99.267				+15.7		+14.3		9.7
4202.198						12.3		
11.127						11.2		
17.720				14.4				
22.382				10.4		13.2		8.0
31.183	+12.1					10.2		11.1
33.772	12.2			11.6		11.9		9.1
38.188	11.4			12.5				10.8
46.968	13.8	+14.2	+11.7	11.5		13.8		13.0
48.384								11.0
50.287		12.4	10.2	11.1	+11.2	12.6	+ 8.5	7.3
50.962		10.8	12.1	9.8		10.2		9.6
54.505		13.1	12.8	9.4	12.6	10.7	9.2	9.0
55.134	10.1				7.4			
57.815					15.3		9.3	
60.640		14.2	12.9		11.5			
65.374							13.0	
67.543					9.5			
68.866							11.1	
71.325					15.0		11.7	
71.934					9.9			
74.935			14.4					
82.127					15.0		9.7	11.5
82.565	12.1	12.9	12.6	10.6	12.7	12.8	10.8	11.5
83.169	16.8	12.3	11.3					
86.627	16.1							
87.605		14.7	13.0	10.3	12.8	12.3		
89.525		13.4			13.5		9.0	
91.630							12.5	
4300.211		17.3	11.2		12.5		9.9	
13.771	13.7	15.6	9.3	9.9	13.1	14.1		
18.867	8.8	11.2	9.1	10.3	10.9		7.8	8.0
25.195	14.8	15.4	13.7					
25.978	14.2	14.1	12.4					
28.101			12.7	11.8	14.1			
31.795					11.8		12.0	
37.216	12.6	13.6		14.3	12.8	10.4	8.5	9.8
37.725	11.9				9.4			
38.084	10.6		11.8		12.8			
40.634	18.1	15.0	13.2		12.3			

Venus—(Continued)

Date	1903 Nov. 22.86	1903 Dec. 12.86	1903 Dec. 19.86			1904 Jan. 5.89	1904 Mar. 1.90	1904 Mar. 14.93
4341.530					14.1			
49.150		9.4			13.4			
52.949			12.0					9.5
55.294					10.6			
59.784	14.0	11.7	10.3		9.8			
67.749	13.5							
69.924	14.2	16.0	14.9					
76.107	16.6	13.5	8.2	10.9			11.5	9.6
79.396	12.0	15.1	11.6	9.0	10.8		13.3	
80.325				6.0				
83.720	8.9	11.7	12.1		11.7	11.4	8.8	
88.629	8.1				7.8			
91.152			10.3					
95.270			9.2					
99.907	14.6							
4404.433	12.4							
04.927		15.5	12.8			11.8		9.4
06.810	14 2	12.1			11.2		8.2	
07.850		12.9	12.5					
15.722	13.1				10.7		10.9	
16.985							8.8	
17.857	14.9			13.8			9.0	11.6
25.608	12.7				16.1	15.8	10.3	9.9
27.444			12.4					
33.414					14.6			
35.817	16.2			14.8	15.3			
42.510	12.8		11.8	8.7	11.3	12.4		10.1
43.976					11.1	14.3		
47.915				9.7	8.5	7.6		7.0
51.752						14.8		
68.647				12.7				
Number of lines	(31)	(25)	(29)	(23)	(36)	(21)	(22)	(23)
Mean	+13.14	+13.51	+11.81	+11.25	+12.03	+11.81	+10.17	+9.59
Scale Corr.	+ 0.11	+ 0.08	+ 0.06	+ 0.05	— 0.02	+ 0.06	— 0.03	—0.01
Systematic Corr.	— 0.22	— 0.22	— 0.22	— 0.22	— 0.22	— 0.22	— 0.22	—0.22
Observed V	+13.03	+13.37		+11.51		+11.65	+ 9.92	+9.36
Computed V	+12.53	+12.57		+12.47		+12.14	+ 9.69	+8.92
$(O-C)$*	+ 0.50	+ 0.80		— 0.96		— 0.49	+ 0.23	+0.44

Mean $O - C$ +.09 km.

* In any consideration of the significance of these quantities it should be borne in mind that the *systematic corrections* were so chosen as to make the mean of all the planet and Moon and sky checks zero.

Moon

Date	1903 Nov. 7.83	1904 May 29.70	1904 Sept. 21.59	1904 Oct. 29.84	1904 Nov. 13.58	1904 Nov. 14.60		1904 Dec. 17.60
Julian day	6426.83	6630.70	6745.59	6783.84	6798.58	6799.60		6832.60
Plate number	35 II	331 III	422 II	453 IV	466 II	469 II		496 IV
Photographed by	W.	W.	W.	W.	P.	P.		P.
Measured by	R.H.C.	W.	W.	W.	W.	P.	A.	P.
λ								
4250.287		—4.2						
50.962	—1.2	—1.2						
54.505	—0.5	—1.9						
55.134	—2.4							
57.815	+0.2							
65.374	+4.4							
67.543	—1.6							
71.325	0.0							
71.934	—0.5							
82.127	—0.7							
82.565	—0.3							
83.169	—2.8	—2.7						
89.525	—2.5							
4300.211	+0.9							
13.771	+1.5	+2.7						
18.867	—0.8							
25.195		+4.6	λ4450 central. System I.	λ4450 central. System I.	λ4450 central. System II	λ4450 central. System I.	λ4450 central. System II	λ4450 central. System I.
28.101	0.0	+2.1						
31.795	+0.9							
37.216	—1.6	0.0						
37.725	+0.2	+0.7						
38.084	+0.5	+5.8						
40.634	+0.2	+1.6						
41.530	+1.4							
49.150	—2.4							
55.294	—4.5							
59.784	—1.7	0.0						
76.107		—5.2						
83.720	+1.7	—0.7						
88.629	—3.7							
99.907		—1.1						
4404.927		+2.3						
06.810	—1.2	+3.1						
15.722	+0.9							
16.985	—4.8							
17.857	+1.6							
25.608	+4.0							
33.414	+0.6							
35.817	+1.9							
42.510	+1.0	—4.8						
43.976	+1.8							
47.915	—2.8	—2.1						
76.107	—0.6							
79.396	—0.9							
Number of lines	(39)	(19)	(26)	(22)	(31)	(36)	(54)	(30)
Mean	—0.35	—0.05	—0.27	—0.44	+0.76	+0.61	—0.08	+0.11
Scale Corr.	.00	.00	.00	.00	.00	.00	.00	.00
Systematic Corr.	— .22	— .22	.00	.00	.00	.00	.00	.00
Observed V	—0.57	— .27	— .27	—0.44	+0.76	+0.26		+ .11
Computed V	—0.98	+0.15	—0.39	—1.48	+0.83	—0.05		+0.73
$(O-C)$*	+0.41	—0.42	+0.12	+1.04 wt. ½	—0.07 wt. ½	+0.31[1] wt. ½		—0.62 wt. ½

Mean $O-C = +0.20$ km.

[1] The value $O-C$ for this plate used in the discussion on page 79 is that depending only on the observation by Dr. Palmer, Dr. Albrecht's measure not being available at the time.

* In any consideration of the significance of these quantities it should be borne in mind that the *systematic corrections* were so chosen as to make the mean of all the planet and Moon and sky checks zero.

GENERAL CATALOGUE

GENERAL CATALOGUE.

No.	Name of Star	A.G.C.	α 1900		δ 1900		Radial Velocity kilometers	Epoch	No. of Plates	Mag. Vis'l	Class	λ 1900		β 1900		*l* cos β
1	*ε Phoenicis*	57	0^h	4.4^m	—46°	18′	— 9.1	1905.22	6	3.9	K	338°	15′	—41°	57′	9.8714
2	*ζ Tucanae*	233		14.9	—65	29	+ 9.2	1905.24	6	4.3	F8G	320	50	—57	43	9.7276
3	*β Hydri*	336		20.5	—77	49	+23.0	1904.55	5	2.9	G	299	29	—64	43	9.6305
4	*α Phoenicis*	355		21.3	—42	51	var.	....	6	2.4	K	344	5	—40	37	9.8803
5	*β Phoenicis*	1024	1	1.6	—47	15	— 1.2	1904.70	6	3.4	K	349	2	—48	12	9.8239
6	*ν Phoenicis*	1174		10.6	—46	4	+11.8	1905.14	5	4.9	G	351	56	—48	7	9.8246
7	*γ Phoenicis*	1411		24.0	—43	50	var.	....	5	3.4	K5M	356	44	—47	35	9.8290
8	*δ Phoenicis*	1462		27.0	—49	35	— 6.9	1905.16	5	4.0	K	352	12	—52	34	9.7838
9	*χ Eridani*	1905		52.0	—52	7	— 5.6	1904.83	4	3.7	G5K	354	46	—57	1	9.7360
10	*ι Eridani*	2851	2	36.7	—40	17	— 9.0	1904.59	4	4.1	K	17	21	—51	43	9.7921
11	*β Fornacis*	3009		44.9	—32	50	+17.3	1905.41	4	4.5	K	24	49	—45	52	9.8428
12	θ^1 *Eridani*	3223		54.5	—40	42	var.	....	4	3.4	A2F	21	53	—53	45	9.7719
13	θ^2 *Eridani*	3224		54.5	—40	42	+17.	1905.45	3	4.4		21	53	—53	45	9.7719
14	*α Fornacis*	3462	3	7.9	—29	23	—20.8	1904.77	5	4.0	F8G	33	12	—44	43	9.8516
15	τ^4 *Eridani*	3607		15.1	—22	7	+42.7[1]	1906.86	3[1]	4.0	Mb	38	43	—38	31	9.8935
16	*κ Reticuli*	3879		27.6	—63	18	+12.3	1905.27	6	4.8	F5G	353	35	—73	48	9.4456
17	*β Reticuli*	4211		42.9	—65	7	var.	....	5	3.8	K	349	56	—76	4	9.3814
18	*γ Hydri*	4353		48.8	—74	33	+15.7	1904.99	4	3.2	Ma	309	0	—76	45	9.3604
19	*α Horologii*	4757	4	10.7	—42	32	+21.4	1905.17	5	3.8	K	44	25	—61	44	9.6755
20	*α Reticuli*	4812		13.1	—62	43	+35.2	1904.53	4	3.4	G5K	6	4	—78	2	9.3166
21	A. G. C. 4821	4821		14.1	—34	3	var.	....	4	3.6	B9A	51	6	—53	57	9.7696
22	d *Eridani*	4940		20.2	—34	14	+22.8	1904.96	5	4.1	K5M	53	4	—54	32	9.7636
23	υ^2 *Eridani*	5187		31.7	—30	46	— 3.2	1905.19	5	3.9	K	58	30	—51	50	9.7910
24	*α Caeli*	5295		37.3	—42	3	+ 1.2	1904.79	5	4.5	F2G	54	44	—63	00	9.6572
25	*β Leporis*	6344	5	24.0	—20	51	—13.7	1904.88	5	3.0	G	78	17	—43	56	9.8574
26	*ε Columbae*	6427		27.7	—35	33	var.	....	5	3.9	K	77	19	—58	39	9.7163
27	*β Doradus*	6561		32.7	—62	33	var.	....	6	3.8	F5G	50	37	—85	3	8.9362
28	*γ Leporis*	6733		40.3	—22	29	— 8.9	1903.81	2	3.8	F8G	83	30	—45	48	9.8433
29	*β Columbae*	6896		47.5	—35	49	+89.2	1904.69	5	3.2	K	85	3	—59	13	9.7091
30	*η Columbae*	7120		56.1	—42	49	+18.7	1905.01	4	4.0	K	88	13	—66	16	9.6048
31	*δ Columbae*	7731	6	18.4	—33	23	var.	....	5	4.0	G5K	97	1	—56	43	9.7393
32	*α Carinae*	7843		21.7	—52	38	+20.5	1904.92	10	0.9	F	103	33	—75	43	9.3924
33	*ν Puppis*	8181		34.7	—43	6	var.	....	5	3.2	B8A	105	46	—66	5	9.6080
34	*τ Puppis*	8568		47.4	—50	30	var.	....	5	2.8	K	116	20	—72	52	9.4692
35	A *Carinae*	8573		47.6	—53	31	var.	....	3	4.4	G5K	119	53	—75	44	9.3919
36	*σ Canis Majoris*	8839		57.7	—27	47	+21.9	1905.47	5	3.7	K5M	110	9	—50	14	9.8060
37	*δ Canis Majoris*	9021	7	4.3	—26	14	var.	....	5	2.0	F8G Pec.	112	0	—48	28	9.8216
38	γ^2 *Volantis*	9206		9.6	—70	20	+ 2.9	1905.21	5	3.9	K	218	32	—82	36	9.1094
39	*ω Canis Majoris*	9198		10.7	—26	35	+32.	1904.97	3	3.8	B3A	114	13	—48	34	9.8208
40	*δ Volantis*	9407		16.9	—67	47	+22.7	1905.25	4	4.0	F5G	198	11	—82	28	9.1174

GENERAL CATALOGUE.

No.	Name of Star	A.G.C.	α 1900		δ 1900		Radial Velocity kilometers	Epoch	No. of Plates	Mag. Vis'l	Class	λ 1900		β 1900		l cos β
41	*η Canis Majoris*	9476	7	20.2	—29	7	+39.	1905.01	4	2.4	B5A Pec.	118	10	—50	38	9.8024
42	*σ Puppis*	9652		26.1	—43	6	var.	....	4	3.3	K5M	127	20	—63	47	9.6451
43	— *Puppis*	9664		26.9	—30	45	+14.2	1905.08	4	4.8	G	121	1	—51	53	9.7904
44	c *Puppis*	10113		41.7	—37	44	+18.0	1905.32	4	3.7	K5M	129	31	—57	45	9.7273
45	*ζ Volantis*	10203		43.0	—72	22	+49.0	1904.86	4	3.9	K	224	26	—79	23	9.2654
46	*ξ Puppis*	10225		45.1	—24	37	+ 4.2	1905.22	5	3.5	G	124	40	—44	57	9.8498
47	a *Puppis*	10343		48.8	—40	19	var.	....	5	3.8	G5K	133	42	—59	42	9.7028
48	B *Carinae*	10904	8	7.3	—60	59	+24.7	1904.65	4	4.8	F5G	173	18	—75	4	9.4109
49	*ε Carinae*	11285		20.4	—59	11	+10.8	1904.93	4	1.7	K Comp.	171	45	—72	41	9.4737
50	*β Volantis*	11407		24.7	—65	48	+27.0	1904.64	4	3.6	K	193	48	—75	34	9.3965
51	*β Pyxidis*	11714		36.2	—34	57	—15.3	1904.62	4	4.0	G5K	145	25	—51	9	9.7974
52	b *Velorum*	11755		37.3	—46	17	+28.6	1905.09	5	4.1	F5G Pec.	154	51	—61	14	9.6824
53	*o Velorum*	11760		37.4	—52	34	var.	....	4	3.7	B3A	163	22	—66	17	9.6045
54	*α Pyxidis*	11806		39.6	—32	49	+16.6	1904.88	5	3.7	B2A	145	7	—48	55	9.8176
55	d *Velorum*	11852		40.8	—42	17	— 1.6	1904.67	4	4.1	G5K	152	18	—57	22	9.7318
56	a *Velorum*	11900		42.6	—45	40	+25.	1905.00	4	4.1	A	156	6	—60	8	9.6972
57	c *Carinae*	12175		52.8	—60	16	+26.	1905.15	5	4.0	B8A	182	18	—70	9	9.5308
58	w *Velorum*	12253		56.3	—40	52	var.	....	4	4.4	F8G	155	39	—54	44	9.7615
59	c *Velorum*	12372	9	0.7	—46	42	+24.2	1904.67	4	3.7	K	162	27	—59	19	9.7078
60	*α Volantis*	12378		0.9	—66	0	vr. (+7.5)[2]	1904.80	4	4.2	A5F	202	13	—71	50	9.4937
61	*λ Velorum*	12438		4.3	—43	2	+18.2	1904.78	5	2.2	K5M	159	49	—55	53	9.7489
62	G *Carinae*	12472		4.9	—72	12	+21.	1904.88	4	4.5	F5G	219	57	—73	16	9.4593
63	a *Carinae*	12535		8.4	—58	33	vr. (+23.3)	....	5	3.6	B3A	181	51	—67	27	9.5838
64	g *Carinae*	12652		13.4	—57	7	— 5.3	1905.07	4	4.2	K5M	180	27	—66	4	9.6082
65	*ι Carinae*	12672		14.4	—58	51	+13.3	1904.99	6	2.2	F	183	54	—67	8	9.5895
66	*κ Velorum*	12788		19.0	—54	35	vr. (+21.9)	....	4	2.6	B3A	177	40	—63	48	9.6450
67	N *Velorum*	13030		28.2	—56	36	—14.2	1904.87	5	3.0	K5M	182	52	—64	14	9.6381
68	l *Carinae*	13336		42.5	—62	3	vr. (+4.)	....	3	var.	G	194	30	—66	27	9.6016
69	*υ Carinae*	13389		44.6	—64	37	+13.9	1904.82	5	3.2	F	201	32	—67	30	9.5829
70	m *Velorum*	13455		47.9	—46	5	var.	....	5	4.6	G5K	174	6	—54	13	9.7669
71	*φ Velorum*	13593		53.4	—54	5	+14.2	1904.92	4	3.7	B5A	184	34	—59	56	9.6998
72	q *Carinae*	14054	10	13.7	—60	50	+ 8.1	1904.73	5	3.4	K5M	198	42	—62	36	9.6629
73	s *Carinae*	14304		24.2	—58	14	+10.4	1904.46	4	4.1	F	196	29	—59	53	9.7005
74	p *Velorum*	14517		33.2	—47	43	var.	....	5	4.1	F2G	186	3	—51	3	9.7984
75	*γ Chamaeleontis*	14557		34.3	—78	6	—22.6	1905.01	5	4.1	Ma	239	4	—68	4	9.5722
76	x *Velorum*	14569		35.3	—55	5	+21.0	1904.95	4	4.4	G	194	22	—56	34	9.7411
77	u *Carinae*	14910		49.4	—58	19	+ 8.2	1904.77	4	3.9	K	201	3	—57	27	9.7294
78	x *Carinae*	15266	11	4.4	—58	26	var.	....	6	4.0	F8G Pec.	203	46	—56	16	9.7445
79	y *Carinae*	15356		8.3	—59	46	— 8.	1904.81	3	4.7	F5G Pec.	206	6	—56	52	9.7376
80	*ξ Hydrae*	15786		28.1	—31	18	— 4.3	1904.58	4	3.7	G5K	186	36	—31	35	9.9304

GENERAL CATALOGUE.

No.	Name of Star	A.G.C.	α 1900		δ 1900		Radial Velocity kilometers	Epoch	No. of Plates	Mag. Vis'l	Class	λ 1900		β 1900		l cos β
81	*— Centauri*	16100	11	41.7	—60	37	— 3.5	1904.70	4	4.2	G	212	26	—54	35	9.7631
82	*η Crucis*	16541	12	1.7	—64	3	+11.	1904.92	4	4.3	F	219	31	—55	27	9.7537
83	*ε Corvi*	16615		5.0	—22	3	+ 4.8[1]	1901.96	6[1]	3.2	K	190	16	—19	39	9.9739
84	*ε Muscae*	16761		12.1	—67	24	+ 6.8	1905.15	3	4.2	Mb	225	10	—57	1	9.7359
85	*ε Crucis*	16835		15.9	—59	51	— 4.6	1904.64	4	3.6	K2M	216	54	—51	12	9.7969
86	*γ Crucis*	17048		25.6	—56	33	+20.6	1904.61	4	1.6	Mb	215	20	—47	49	9.8271
87	*β Corvi*	17129		29.1	—22	50	— 7.5	1905.18	4	2.8	G5K	195	58	—18	2	9.9781
88	*β Crucis*	17411		41.8	—59	8	var.	....	4	1.5	B1A	220	14	—48	38	9.8202
89	*δ Muscae*	17693		55.4	—71	0	+34.7	1904.67	4	3.6	K2M	234	47	—56	46	9.7389
90	*ι Centauri*	18149	13	15.0	—36	11	+ 1.	1904.96	4	2.9	A2F	211	45	—26	0	9.9537
91	d *Centauri*	18376		25.2	—38	54	— 3.5	1904.76	4	4.0	K	215	5	—27	37	9.9475
92	*ν Centauri*	18772		43.5	—41	12	var.	....	6	3.5	B2A	219	46	—28	16	9.9448
93	*μ Centauri*	18773		43.6	—41	59	+12.	1905.01	4	3.3	B2A Pec.	220	9	—28	58	9.9419
94	*υ² Centauri*	19027		55.4	—45	7	var.	....	5	4.4	F5G	223	53	—30	58	9.9332
95	*π Hydrae*	19128	14	0.7	—26	12	+27.4	1905.37	4	3.5	K	217	14	—13	2	9.9887
96	*θ Centauri*	19129		0.8	—35	53	+ 2.0	1904.69	4	2.3	K	220	55	—22	2	9.9670
97	*δ Octantis*	19284		10.9	—83	13	+ 5.0	1905.30	4	4.1	K2M	257	39	—62	19	9.6670
98	*η Centauri*	19737		29.2	—41	43	var.	....	4	2.6	B3A Pec.	228	52	—25	30	9.9555
99	*α² Centauri*	19825		32.8	—60	25	(—22.2)	1904.70	6	0.3	G	238	13	—42	33	9.8672
100	*α¹ Centauri*	19826		32.8	—60	25	(—22.2)	1904.70	6	1.7	K5M	238	13	—42	33	9.8672
101	*α Circini*	19849		34.4	—64	32	+ 7.7	1904.68	4	3.4	F	241	38	—47	4	9.8332
102	*α Lupi*	19873		35.3	—46	58	var.	....	4	2.9	B2A	232	6	—30	1	9.9375
103	*α Apodis*	19851		35.4	—78	37	+ 0.4	1905.02	4	3.8	K5M	253	3	—58	14	9.7214
104	c¹ *Centauri*	19931		37.5	—34	44	—38.7	1905.05	5	4.1	K	227	59	—18	22	9.9773
105	*β Lupi*	20263		52.0	—42	44	var.	....	4	2.8	B2A Pec.	233	38	—25	2	9.9572
106	*κ Centauri*	20286		52.7	—41	42	var.	....	4	3.4	B3A	233	23	—24	1	9.9606
107	*ζ Lupi*	20572	15	5.1	—51	43	—10.0	1904.94	4	3.5	K	239	22	—32	49	9.9245
108	*φ¹ Lupi*	20793		15.5	—35	54	—30.4	1905.10	4	3.6	K5M	236	7	—17	10	9.9802
109	*υ Librae*	21146		30.9	—27	48	—25.0[1]	1905.82	4[1]	3.8	K2M	237	12	— 8	30	9.9952
110	*δ Triang. Aust.*	21939	16	6.4	—63	26	— 5.1	1904.91	4	4.0	G	253	28	—41	36	9.8738
111	*γ Apodis*	22170		18.1	—78	40	var.	....	4	3.9	K	261	19	—56	0	9.7475
112	*α Scorpii*	22314		23.3	—26	13	v.(—2½±)	....	5	1.2	Ma Comp.	248	21	— 4	34	9.9986
113	*τ Scorpii*	22451		29.7	—28	1	+ 1.4	1904.95	4	2.9	B	250	4	— 6	6	9.9975
114	H *Scorpii*	22454		29.8	—35	3	— 1.5	1905.33	3	4.3	Ma	251	12	—13	4	9.9886
115	*α Triang. Aust.*	22607		38.1	—68	51	— 3.2	1904.87	4	1.9	K2M	259	30	—46	9	9.8406
116	*η Arae*	22672		41.1	—58	52	+ 9.9	1905.07	4	3.7	K5M	257	30	—36	16	9.9065
117	*ε Scorpii*	22731		43.7	—34	7	— 2.2	1904.87	4	2.4	K	253	58	—11	43	9.9908
118	*μ² Scorpii*	22778		45.6	—37	51	+ 1.	1905.19	4	3.6	B2A	254	52	—15	22	9.9842
119	*ζ² Scorpii*	22832		47.6	—42	12	—19.2	1904.85	4	3.8	K5M	255	51	—19	38	9.9740
120	*ζ Arae*	22916		50.3	—55	50	— 6.3	1904.78	4	3.1	K5M	258	26	—33	5	9.9232

GENERAL CATALOGUE.

No.	Name of Star	A.G.C.	α 1900		δ 1900		Radial Velocity kilometers	Epoch	No. of Plates	Mag. Vis'l	Class	λ 1900		β 1900		l cos β
121	*β Arae*	23516	17	17.0	—55	26	— 1.2	1904.77	4	2.8	K2M	262	49	—32	16	9.9271
122	*υ Scorpii*	23698		24.0	—37	13	var.	....	4	2.8	B3A	262	37	—14	0	9.9869
123	*η Pavonis*	23958		35.9	—64	41	— 8.5	1904.98	4	3.6	K	266	34	—41	18	9.8758
124	*ι' Scorpii.*	24107		40.6	—40	5	—27.7	1904.89	4	3.1	F5G Pec.	266	6	—16	51	9.9810
125	G *Scorpii*	24179		43.0	—37	1	+24.5	1904.86	4	3.2	K2M	266	31	—13	37	9.9876
126	*π Pavonis*	24559		58.9	—63	40	—19.5	1904.92	4	4.4	A5F	269	50	—40	13	9.8829
127	*γ Sagittarii*	24596		59.4	—30	26	vr.(+22±)	1904.93	4	3.1	K	269	52	— 7	10	9.9966
128	*η Sagittarii*	24888	18	10.9	—36	47	+ 0.2	1905.45	4	3.2	Mb	272	15	—13	22	9.9881
129	*δ Sagittarii*	24987		14.6	—29	52	—19.7	1905.28	2	2.8	K	273	11	— 6	28	9.9972
130	*ε Sagittarii*	25060		17.5	—34	26	—13.	1905.01	4	2.0	A	273	42	—11	1	9.9919
131	*α Telescopii*	25105		19.6	—46	1	— 1.	1904.97	4	3.8	B3A	273	38	—20	23	9.9719
132	*ζ Telescopii*	25140		21.1	—49	7	—30.1	1905.13	4	4.1	K	273	50	—25	44	9.9546
133	*λ Sagittarii*	25171		21.8	—25	29	—43.2	1905.36	2	2.9	K	274	55	— 2	6	9.9997
134	*ζ Pavonis*	25383		31.4	—71	31	—17.0	1905.38	4	4.1	K	273	43	—48	10	9.8241
135	*κ Pavonis*	25786		46.6	—67	21	var.	....	4	var.	F5G	276	7	—44	8	9.8559
136	*τ Sagittarii*	26149	19	0.7	—27	49	var.	....	2	3.4	K	283	26	— 5	4	9.9983
137	*π Sagittarii*	26225		3.8	—21	11	—11.9	1903.73	2	3.0	F2G	284	51	+ 1	27	9.9998
138	*ι Sagittarii*	27239		48.4	—42	8	+35.4[1]	1906.55	3[1]	4.2	K	291	9	—20	39	9.9712
139	*δ Pavonis*	27468		58.9	—66	26	—22.6	1904.83	5	3.6	G5K	286	11	—44	39	9.8522
140	*α Pavonis*	27918	20	17.7	—57	3	vr. (+2.0)	....	4	2.1	B3A	292	25	—36	15	9.9066
141	*α Indi*	28213		30.5	—47	38	— 1.6	1904.95	4	3.2	K	297	43	—27	46	9.9469
142	*β Indi*	28615		47.0	—58	50	— 6.6	1905.14	4	3.7	K	296	23	—39	8	9.8897
143	*γ Pavonis*	29309	21	18.2	—65	49	—30.0	1905.33	4	4.3	F8G	297	10	—47	0	9.8338
144	*ν Octantis*	29533		30.4	—77	50	var.	....	4	3.7	K	288	18	—57	46	9.7271
145	*α Tucanae*	30422	22	11.7	—60	45	+39.9	1905.05	6	2.9	K2M	308	15	—45	24	9.8464
146	*δ' Gruis*	30647		23.3	—44	0	+ 5.8	1905.53	5	4.0	G5K	320	12	—31	20	9.9315
147	*β Gruis*	30913		36.7	—47	24	+ 0.6	1905.42	6	2.2	Mb	320	56	—35	25	9.9111
148	*δ Piscis Aust.*	31184		50.4	—33	4	—12.0	1905.43	4	4.3	K	330	48	—23	38	9.9620
149	*ζ Gruis*	31263		55.0	—53	17	var.	....	5	4.2	G5K	320	32	—41	58	9.8712
150	*ι Gruis*	31445	23	4.7	—45	47	var.	....	6	4.1	K	327	6	—36	14	9.9066

[1] One plate only of each of these three stars was secured in Chile during the period covered by the observations. Mt. Hamilton and more recent Chilean observations have therefore been used in determining the catalogue values. See details of observations.

[2] See note on p. 176.

STARS HAVING VARIABLE VELOCITIES.

Of the 150 stars included in the foregoing catalogue quite a number have been found to have variable velocities. Forty-one cases of such variation have been fully established and most of these have been announced in astronomical publications. For convenience they are collected here. There are, in addition, a number of stars the constancy of whose velocity is subject to great doubt, but which have not yet been included in the list of proved spectroscopic binaries. Some of these doubtful cases have been referred to in notes attached to the observations.

α Centauri is included in the list, although no variation has been detected in the velocity of either component. The difference in radial velocity, due to relative orbital motion between the

Star	R.A. (1900)	Decl. (1900)	Extreme Values Observed km.	km.	No. of Observations	Magnitudes	Spectral Class	Variation Detected by
α Phoenicis	0h 21m3	—42° 51′	+71	+ 80	6	2.4	K	Wright
γ Phoenicis	1 24.0	—43 50	—33	+ 40	5	3.4	K5M	Palmer
θ¹ Eridani	2 54.5	—40 42	—81	+110	4	3.4	A2F	Wright
β Reticuli	3 42.9	—65 7	+47	+ 54	5	3.8	K	Palmer
A. G. C. 4821	4 14.1	—34 3	—26	+ 63	4	3.6	B9A	Wright
ε Columbae	5 27.7	—35 33	— 7	— 2	5	3.9	K	Wright
β Doradus	5 32.7	—62 33	+ 1	+ 28	6	3.8	F5G	Palmer
δ Columbae	6 18.4	—33 23	—16	0	5	4.0	G5K	Palmer
ν Puppis	6 34.7	—43 6	+20	+ 35	8	3.2	B8A	Wright
τ Puppis	6 47.4	—50 30	+33	+ 39	5	2.8	K	Palmer-Curtis
A *Carinae*	6 47.6	—53 31	+ 2	+ 48	3	4.4	G5K	Wright
δ Canis Majoris	7 4.3	—26 14	+33	+ 38	16	2.0	F8G Pec.	Wright
σ Puppis	7 26.1	—43 6	+86	+103	4	3.3	K5M	Palmer
a *Puppis*	7 48.8	—40 19	+11	+ 27	5	3.8	G5K	Wright
o Velorum	8 37.4	—52 34	+10	+ 27	12	3.7	B3A	H. D. Curtis
w *Velorum*	8 56.3	—40 52	+ 3	+ 15	4	4.4	F8G	Palmer
α Volantis	9 0.9	—66 0	—51	+ 8	5	4.2	A5F	Wright
a *Carinae**	9 8.4	—58 33	— 1	+ 44	25	3.6	B3A	Wright
*κ Velorum**	9 19.0	—54 35	—29	+ 67	27	2.6	B3A	Wright
l *Carinae*	9 42.5	—62 3	—17	+ 23	17	var.	G	Wright
m *Velorum*	9 47.9	—46 5	— 4	+ 12	5	4.6	G5K	Wright
p *Velorum*	10 33.2	—47 43	—10	+ 39	5	4.1	F2G	Wright
x *Carinae*	11 4.4	—58 26	+ 3	+ 18	9	4.0	F8G Pec.	Wright
β Crucis	12 41.8	—59 8	+ 6	+ 25	10	1.5	B1A	Wright
ν Centauri	13 43.5	—41 12	—15	+ 31	6	3.5	B2A	Palmer
υ² Centauri	13 55.4	—45 7	— 8	+ 5	5	4.4	F5G	Wright
η Centauri	14 29.2	—41 43	—11	+ 6	7	2.6	B3A	Wright
α Centauri	14 32.8	—60 25	—25	— 19	12	0.3 1.7	G, K5M	Wright
α Lupi	14 35.3	—46 58	0	+ 17	10	2.9	B2A	Wright
β Lupi	14 52.0	—42 44	— 8	+ 8	6	2.8	B2A Pec.	
κ Centauri	14 52.7	—41 42	+ 4	+ 16	10	3.4	B3A	H. D. Curtis*
γ Apodis	16 18.1	—78 40	+ 2	+ 8	7	3.9	K	Wright
α Scorpii	16 23.3	—26 13	— 6	+ 2	24	1.2	Ma Comp	Wright
υ Scorpii	17 24.0	—37 13	— 2	+ 38	8	2.8	B3A	Wright
γ Sagittarii	17 59.4	—30 26	+18	+ 24	8	3.1	K	Wright
κ Pavonis	18 46.6	—67 21	+24	+ 37	4	var.	F5G	Wright
τ Sagittarii	19 0.7	—27 49	+24	+ 59	6	3.4	K	H. D. Curtis-Wright
*α Pavonis**	20 17.7	—57 3	— 6	+ 10	22	2.1	B3A	Albrecht
ν Octantis	21 30.4	—77 50	+28	+ 36	4	3.7	K	Wright
ζ Gruis	22 55.0	—53 17	— 9	+ 2	8	4.2	G5K	Wright
ι Gruis	23 4.7	—45 47	+ 7	— 18	9	4.1	K	Wright

TABLE OF STARS HAVING VARIABLE RADIAL VELOCITIES—*(Continued.)*

two components, has, however, been accurately determined. *β Lupi*, the binary character of which was discovered by Mrs. Flemming, is also included for completeness, though our observations themselves do not more than afford a strong suspicion of the star's variable velocity.

An asterisk following the name of a star in the first column of the following table indicates that the spectroscopic orbit has been computed. In such cases the elements will be found in the addendum to this volume. In the eighth column is given the name of the observer who detected the variation. In a few cases the discovery was independently made by two persons and in such instances the names of both are given. Further than this the table hardly requires explanation.

	Remarks
θ¹ Eridani	Both spectra present and apparently of same class. As this star is one of a telescopic pair the system is a triple one
A. G. C. 4821	Both spectra present, and apparently of the same class. The masses of the two components are very nearly equal
ν Puppis	Secondary spectrum possibly present
δ Canis Majoris	Period is about 275 days
a Volantis	Both spectra present. Later observations by Curtis, as yet incompletely reduced, show greater range in velocity. The eccentricity is probably large. The ratio of the masses appears to be about 6:5, the brighter being the heavier
a *Carinae**	Both spectra probably present
l *Carinae*	Cepheid variable. The data here given include later results by Curtis and Albrecht
p *Velorum*	Both spectra present. They differ somewhat in type and considerably in intensity. The ratio of the masses appears to be about as 9:5, the brighter being the heavier
ν Centauri	Period probably about 31 days
η Centauri	Spectrum described as composite by Miss Cannon
β Lupi	Spectrum described as composite by Mrs. Flemming. See remarks, p. 245
a Scorpii	Spectrum described as composite by Miss Maury. See remarks, p. 257. The results here summarized cover observations made at Mt. Hamilton
κ Pavonis	Cepheid variable
τ Sagittarii	Results here given include Mt. Hamilton observations

WAVE LENGTHS OF LINES IN THE SPECTRA OF α CARINAE AND υ CARINAE

A number of stars of the types classified between F. and G. have broad and hazy lines, the positions of which can be determined only by a study of the spectra of stars of some closely related class in which the lines are sharp. In the latter spectra it is easy to identify certain of the dark lines whose wave-lengths are known, and from these to determine the wave-lengths of such as appear suitable for measurement in the broad-line stars. With this end in view two spectrograms each of α *Carinae* and υ *Carinae* were measured between the limits 4144A and 4590A. A list of lines, including a few blends, which were regarded as suitable for measurement in the broad line stars previously referred to, was then selected, and this has been given on page 77. The full list, containing all lines visible on the spectrograms (between the limits set) is given below in the belief that the wave lengths and estimates of intensity may be of use for purposes other than those for which the measurements were primarily made. The intensity scale ranges from 1, which indicates a well defined line, to 10 corresponding to the Hγ line in υ *Carinae*. Faint lines are indicated by 0 and in a few cases by the symbol 00, which indicates a line just on the limit of visibility. This scale is far too limited to indicate definitely the relative intensities of the different spectral lines but will, I believe, be found accurate as far as it goes. The wave-lengths have been corrected for radial velocity as determined from numerous Iron and Titanium lines. In common with all those used in this volume they are based on Rowland's system.

α Carinae λ	i	υ Carinae λ	i	
4144.0	2			
45.2	0	4145.3	0	
45.9	0	45.9	0	
47.7	0	47.7	0	
49.40	2	49.45	2	
51.1	00	51.1	0	
52.2	1	52.3	0	
54.05	1	54.02	0	
54.81	1	54.81	0	
56.38	1	56.37	0	
56.92	1	56.9	0	
57.88	1	57.9	0	
59.1	0	....		
61.3	1	....		
61.67	1½	61.65	2	Broad hazy line.
63.79	2	63.80	3	
67.44	1+	67.4	1½	
68.1	00	....		
....		68.8	0	
71.14	1	71.1	1—	
72.08	3	72.06	2	
72.80	1	72.82	1—	
73.65	3	73.63	3	

α Carinae (*Continued*) λ	*i*	υ Carinae (*Continued*) λ	*i*	
4174.4	1—	4174.3	0	
75.1	0	....		
75.8	0	75.8	0	
76.8	1—	76.8	0	
77.76	3+	77.79	2	
79.06	2	79.03	2	
79.54	1	79.57	0	
81.93	1+	81.93	1	
83.58	1—	83.58	0	
84.1	00	....		
84.48	1	84.48	1—	
85.06	1—	85.08	0	
87.23	1+	87.26	1	
87.94	2—	87.93	1	
88.92	0	....		
90.48	0	90.5	00	
91.60	1	91.58	1	
92.2	0	92.1	0	
95.56	1	95.5	1—	
96.4	0	96.4	00	
98.41	2—	98.42	1½	
99.26	2—	99.25	1	
4201.1	0	....		
02.24	2	4202.29	2	Blend. Intense on violet edge.
04.18	1—	04.2	1—	
05.38	1½	05.3	1	Broad, hazy line.
07.4	0	....		
09.0	1—	09.1	1	Hazy. Double?
09.9	0	....		
10.50	1	10.48	1	
12.02	1—	12.02	0	
13.8	0	....		
15.70	5	15.68	3+	
16.34	0	....		
17.73	0	17.75	0	
19.52	1	19.54	0	
20.3	0	....		Hazy
22.36	1—	22.38	1—	
24.34	1—	24.32	1—	
....		24.9	0	
25.52	1—	25.5	0	
26.88	3—	26.88	2	
27.54	2	27.57	1½	
33.33	3½	33.35	3	
33.77[1]	1	33.71	1	
36.07	2	36.08	2	

[1] Difficult on account of proximity to preceding line.

α CARINAE (*Continued*) λ	i	υ CARINAE (*Continued*) λ	i	
4238.2	0	....		
38.96	1—	4238.99	1	
39.9	0	39.8	0	
40.6	0	....		
42.52	2	42.54	2	
45.42	0	45.5	0	
46.3	0	....		
47.00	3½	46.98	3	
47.60	1	47.63	1	
50.28	2—	50.28	2	
50.94	2½	50.95	2	
		51.9	0	
52.78	1	52.81	1	
54.52	2	54.50	2	
58.33	3	58.32	3	
60.64	2	60.65	2	
62.06	2	62.04	2	
63.4	00			
67.1	00			
67.98	0	67.9	00	
69.40	1	69.38	1—	
71.29	1+	71.32	1	
71.93	3—	71.91	2	
73.50	2	73.50	2	
74.94	2	74.94	1½	
75.70	2	75.73	2	
78.34	1+	78.34	1	
82.53	1½	82.59	1	
83.17	1—	83.3	00	
84.35	1	84.35	1½	
85.6	0	....		
87.2	00	....		
88.07	2	88.06	2	
89.5	0	....		
89.92	1—	89.9	0	
90.40	3—	90.42	3	
94.26	3	94.25	3	
94.96	1—	94.9	1—	
96.76	2	96.75	2	
98.2	00	98.0	00	
99.34	2	99.32	1	
4300.22	3	4300.22	3	
02.09	2+	02.08	2	
02.68	1	02.8	1—	
03.37	2	03.38	2	
05.84	1+	05.84	1	Broad, hazy line
08.02	3½	08.05	3	
09.0	0	....		

α Carinae (*Continued*)

λ	i
4309.76	1
13.04	3—
14.32	4—
15.16	3—
16.98	1
18.84	1—
20.98	4
25.16	2
25.92	3
26.8	0
30.41	1
30.86	1
33.8	00
37.23	1—
38.08	2½
40.60	8
41.51	1—
44.46	2—
51.00	1
51.96	3
52.88	1
54.71	1—
57.71	0
58.83	0
59.86	1—
61.4	00
62.3	0
67.84	2—
69.56[2]	1
69.9	0
71.1	0
71.6	0
74.66	2—
75.04	2—
76.14	1
79.96	0
83.72	3—
84.43	1—
84.96	1—
85.56	2
87.02	1½
88.8	0
90.8	00
91.22	1—
91.9	0
94.24	2—
95.21	3

υ Carinae (*Continued*)

λ	i
4309.7	1—
13.04	3
14.32	3
15.14	3
16.94	1
18.8	0
20.99	3
25.12	2
25.92	2
....	....
30.42	1
30.87	1
....	....
37.2	0
38.08	1½
40.62	10
41.5	0
44.44	1½
51.02	1
51.96	3
52.88	0
54.66	0
57.7	0
58.9	0
59.9	0
....	....
62.2	0
67.81	1½
69.6[2]	1
71.3	0
74.65	2
75.08	2
76.16	1—
79.90	0
83.70	2
84.44	1—
84.83	1—
85.56	2
86.98	2
88.4	
90.7	0
91.18	1
....	....
94.21	1½
95.22	3

[2] The close companion on the less refrangible side possibly influences the measures.

a Carinae (Continued) λ	i	υ Carinae (Continued) λ	i	
4396.00	2—	4396.06	1½	
98.30	1	98.2	1	
99.93	2	99.93	2	
4400.58	2	4400.54	1½	
01.67	0	....		
04.92	2	04.90	2	
07.88	1—	07.90	1—	
08.56	0	....		
09.55	1	09.53	1	
11.25	1	11.26	1	
12.10	1—	12.16	0+	
13.76	1—	13.74	0	
15.28	2—	15.30	1	
15.73	1+	15.74	1	
16.98	2	16.99	2	
17.87	2	17.86	2	
18.53	1+	18.54	1	
22.1	0	22.1	0	
22.74	1—	22.8	00	
25.56	0	....		
27.42	0	27.3	0	
30.7		....		Between these limits there is a group of fine lines
34.1		....		
35.13	0	....		
35.82	0	....		
40.7	00	....		
41.86	1—	41.9	1—	
42.52	1	42.54	0	
43.2	1—	43.2	1—	
44.00	2½	43.97	3—	
44.72	1	44.72	1+	
47.88	0+	47.88	0+	
50.66	2	50.67	2	
51.71	0	51.77	1	
53.4	00	....		
53.9	0	....		
54.99	1—	54.9	1—	Line hazy.
56.0	00			
59.26	1	59.28	1	
61.70	1	61.68	1½	
64.68	2	64.62	2—	
66.73	1—	66.75	1—	
68.67	3—	68.65	3	
69.40	1	69.46	1	
71.02	1	70.98	1+	
73.12	1	73.12	1+	
76.20	1	76.19	1	

α Carinae (*Continued*) λ	i	υ Carinae (*Continued*) λ	i
4481.40	4	4481.38	4
82.36	1	82.4	0
88.50	2—	88.49	1
89.37	2	89.36	2
91.59	2+	91.60	2
93.70	1—	93.70	0
94.78	1+	94.68	1—
97.10	1—	....	
4500.6	0	....	
01.46	3	4501.44	3—
08.45	2	08.44	2+
15.50	2	15.54	2+
18.50	1—	18.53	1—
20.39	2	20.36	2+
22.78	3—	22.78	3—
25.2	1—	25.2	0
26.6	00		
28.75	1+	28.76	1½
29.67	1+	29.67	1½
31.3	0	....	
34.18	3	34.20	3
39.8	0	39.7	0
41.71	1+	41.74	2
44.11	0	....	
45.3	0	45.4	
48.1	00	....	
49.72	4+	49.72	5—
52.50	0	52.5	00
54.18	1½	54.2	1
55.18	1—	55.2	0
56.04	2—	56.06	2—
58.78	2—	58.80	2
63.88	2—	63.92	2
64.7	0	....	
65.8	0	65.8	1
68.6	00	....	
72.14	2+	72.16	2
76.47	1	76.51	1+
80.2	0	80.3	1
....		81.7	00
82.98	1	83.0	1
84.00	2	84.04	3—
89.3	1	....	
90.1	1	....	

Comparisons have been made between the above and various other tables of wave-lengths. In particular it has been compared with Dr. H. M. Reese's tables of the enhanced lines of Titanium and Iron [1]. The region common to both Reese's table and the above one lies between λ 4225

[1] *Astrophysical Journal*, **19**, 322.

and λ 4590. Within these limits Hasselberg and others give nearly 200 titanium lines. About 43 of these have been identified in the stellar spectra under discussion, and of these practically all are noted enhanced in Reese's table. Furthermore, substantially all his enhanced titanium lines are found in the stellar spectra. There are of course certain lines in the latter, the origins of which are open to doubt, as, for instance, those which have their counterparts in the spectra of two or more elements active in the star. It is neither practicable nor desirable to consider these comparatively few exceptional cases in this brief discussion, but the general statement may be made that, within the limits covered by both tables, the titanium lines occurring in the spectra of these stars are those, and only those, given by Reese as enhanced.

With regard to the spectrum of iron the case is not so simple. A number of enhanced lines are found in the accompanying table but certain strong iron lines not placed in this class by Reese are also recorded. Then again some of his enhanced lines do not occur in these stellar spectra. For instance, the strongly enhanced line at λ 4268.94 does not correspond with anything in the stellar spectra while its somewhat more intense, though unenhanced, neighbor is undoubtedly identical with the stellar line λ 4271.31. The relation, if there is any, between enhancement in the spark, and occurrence in spectra of which those of α and υ *Carinae* may be said to be prototypes, is therefore more obscure in the case of iron than in that of titanium.

The following elements have been identified with a reasonable degree of certainty as existing in these two stars: Iron, Titanium, Calcium, Scandium, Magnesium, Chromium, and Hydrogen. Barium, Yttrium, Strontium, and Vanadium are possibly present. Many other elements have several lines coinciding approximately with stellar lines, but on account of the limited extent of spectrum covered by the measures it is impossible to form an opinion as to the probability of their presence. Many of the stellar lines are of doubtful origin, and among these may be mentioned the following:

λ (*)	*i*	λ (☉) (Rowland)	*i*
4167.44	1½	67.44	8
77.78	3	{77.70 {77.77	3 3
79.04	2	79.02	3
4242.53	2	42.54	2
52.80	1	52.79	0
58.32	3	Not in ☉	
62.05	2	62.09	1
69.39	1	69.45	0
75.72	2	75.71	0
84.35	1+	84.38	2
4369.58	1	69.57	1
94.22	1½	94.22	2
4416.98	2	16.98	2
73.12	1+	73.09	0
89.36	2	89.35	2
4518.52	1—	18.51	1
55.18	1—	55.16	2

Nearly all of them appear to have counterparts in the solar spectrum as indicated in the table. In considering such coincidences, however, it is necessary to bear in mind two things. The first is that the solar spectrum is so crowded with lines (the average distance between two consecutive ones being in this region of the spectrum between .010 and .020 Angstroms) that a close agreement in wave-length with some solar line is almost certain to occur for any value of λ that one

may suggest. The second is that the two intensity scales are different. Rowland's scale runs to 1000, with an extensive series of zero ratings for extra faint lines, while that adopted by the writer extends only to 10. Therefore a line rated at 2, 3 or 4 in the star is much stronger than one whose intensity in the Sun is indicated by the same figure. It is therefore doubtful whether some of the coincidences indicated in the table, particularly those in which the intensity of the solar line is less than unity, are of any significance. It may therefore be tentatively assumed that the following five stellar lines have no counterparts in the solar spectrum.

λ	i
4252.80	1
4258.32	3
4269.39	1
4275.72	2
4473.12	1+

ADDENDUM

THE ORBITS OF THREE SPECTROSCOPIC BINARIES DISCOVERED BY THE D. O. MILLS EXPEDITION

BY HEBER D. CURTIS

Reprinted from Lick Observatory Bulletin, No. 122

ORBIT OF THE SPECTROSCOPIC BINARY a CARINAE

($\alpha = 9^h\ 8^m\!.4$; $\delta = -58°\ 33'$.)

The binary character of this star was discovered by Professor W. H. Wright in the course of the work of the D. O. Mills Expedition to the Southern Hemisphere.* It is of visual magnitude 3.5, and the exposure time used has been fifty to sixty minutes under average observing conditions. It contains, in the part of the spectrum covered by the spectroscope of the Mills Reflector, only the following six lines:

λ 4267.316	C	
4340.634	H	
4388.100	He	
4437.718	He;	generally rather faint
4471.646	He	
4481.400	Mg	

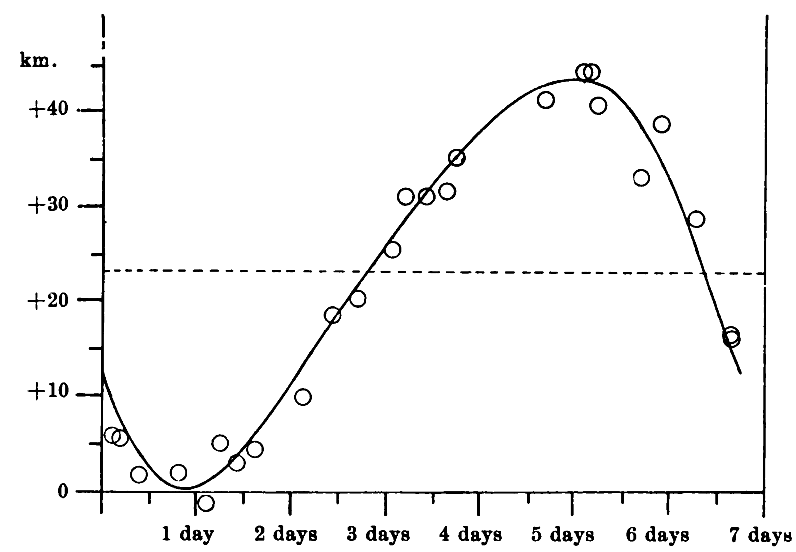
The star is given as Type B3A in the Harvard classification, and the lines are of quite fair quality for this type of spectrum.

The orbit depends upon the following twenty-five plates:

No.	Plate	G.M.T.	Vel.	Measurer	O.—C
1	199 I	1904, Feb. 29.671	+ 5.5 km. + 6.0	Wright Palmer	—3.4
2	570 II	1905, Jan. 30.683	+32.6 +33.8	Wright Palmer	—5.1
3	588 II	Feb. 9.640	+ 9.2 +10.9	Wright Palmer	—3.2
4	607 III	22.617	+ 4.2 + 4.8	Wright Palmer	—1.4
5	617 II	Mar. 7.577	— 1.2	Palmer	—2.0
6	911 IV	1906, Mar. 30.578	+ 3	Curtis	+0.9
7	1071 III	1907, Jan. 15.789	+39.0	Curtis	+4.8
8	1077 II	19.814	+31.1	Curtis	+2.4
9	1084 II	21.755	+44.4	Curtis	+1.6
10	1102 II	25.810	+18.6	Curtis	+0.7
11	1107 II	26.786	+31.2	Curtis	—0.4
12	1128 IV	Feb. 2.751	+31.8	Curtis	—2.4
13	1140 III	5.768	+16.2	Curtis	+1.6
14	1145 III	6.665	+ 2.0	Curtis	+1.8
15	1151 III	19.734	+ 1.9	Curtis	—2.1
16	1162 IV	Mar. 2.739	+41.3	Curtis	—1.3
17	1167 IV	4.736	+16.7	Curtis	+1.9
18	1183 III	14.625	+25.7	Curtis	—1.0
19	1188 III	16.634	+44.3	Curtis	+1.3
20	1195 III	19.574	+ 5.2	Curtis	+3.3
21	1199 II	23.528	+40.8	Curtis	—2.3
22	1208 IV	24.582	+28.8	Curtis	+3.4
23	1282 II	April 30.489	+20.4	Curtis	—0.9
24	1294 II	May 1.496	+35.2	Curtis	+0.1
25	1319 II	11.476	+ 5.7	Curtis	—1.2

* *Lick Obs. Bulletin*, No. 75, 1906.

An orbit was computed graphically from these values by the method of Lehmann-Filhés.† These elements were then tested and changed by varying the elements after comparison with the observed velocities so as to give as close as possible a representation of the observations. The following elements resulted:



VELOCITY CURVE OF *a* CARINAE.

Period $= 6.744$ days
$T =$ J. D. 2416533.81
$\omega = 115^\circ.84$
$K = 21.5$
$\mu = 53^\circ.380$
$e = 0.18$
Velocity of system $= +23.3$ km.
$a \sin i = 1{,}960{,}000$ km.

A least square solution would not be warranted by the number and character of the lines available for measurement.

In the accompanying figure I have plotted the separate observations with the orbit curve, the dotted line representing the velocity of the center of mass of the system. The actual residuals, in the sense observed minus computed, are given in the last column of the table of plates. While some of these are rather large they are not excessive when the character and number of the lines used is taken into account.

THE D. O. MILLS EXPEDITION,
SANTIAGO, CHILE, June, 1907.

† *A. N.*, 136, 17, 1894

ORBIT OF THE SPECTROSCOPIC BINARY *a* PAVONIS

The binary character of *a Pavonis* ($\alpha = 20^h\,17^m.7$; $\delta = -57^\circ\,0'.3$) had been suspected by Professor W. H. Wright in Chile from preliminary measures of the first four plates taken, and has been independently discovered from the definitive reductions of the same plates made by Dr. S. Albrecht at Mt. Hamilton. The star is of the type B3A, similar to *a Carinae* and *κ Velorum*, though the lines are doubtless somewhat better than in these stars. Its visual magnitude is 2.0. Under fair observing conditions satisfactory

plates can be secured in twenty-two to twenty-six minutes.

The following twenty-two plates form the basis of the elements derived in this paper:

No.	Plate	G.M.T.		Vel.	Measurer	O.—C
1	17 I	1903, Sept.	23.582	+ 2.0 km.	Palmer	—0.9
2	333 II	1904, May	29.909	+ 9.5	Albrecht	+0.3
3	756 IV	1905, Aug.	3.697	— 0.9	Albrecht	+1.9
4	785 III	Aug.	25.676	— 4.2	Albrecht	+1.1
5	935 II	1906, Oct.	7.571	+ 3.3	Paddock	—1.4
				+ 2.1	Curtis	
6	966 II	Nov.	6.514	+ 0.4	Paddock	—1.1
				+ 1.5	Curtis	
7	1292 III	1907, April	30.924	— 1.5	Paddock	+0.7
				+ 0.9	Curtis	
8	1323 III	May	11.831	— 3.8	Curtis	—0.2
9	1336 IV	May	13.880	+ 4.5	Curtis	+0.1
10	1343 IV	May	14.886	+ 7.3	Curtis	—0.3
11	1349 II	May	18.835	+ 4.5	Curtis	+1.3
12	1382 II	June	22.884	+ 2.9	Curtis	—1.1
13	1400 IV	June	26.764	— 5.8	Curtis	—0.7
14	1407 II	July	1.886	+10.4	Curtis	+1.3
15	1411 IV	July	2.685	+ 8.7	Curtis	—0.3
16	1418 II	July	3.768	+ 7.3	Curtis	+0.5
17	1428 IV	July	6.804	— 2.4	Curtis	+1.2
18	1435 III	July	19.742	— 5.8	Curtis	—0.5
19	1441 IV	July	20.767	— 4.0	Curtis	+0.4
20	1445 II	July	25.645	+ 7.7	Curtis	—1.5
21	1451 I	July	27.778	+ 5.9	Curtis	+0.7
22	1456 II	July	29.630	— 2.6	Curtis	—1.1

The lines upon which the above radial velocities depend are the six characteristic lines of this type, no others being visible in this region of the spectrum.

λ 4267.316	C
4340.634	H
4388.100	He
4437.718	He
4471.646	He
4481.400	Mg

A set of preliminary elements was first derived graphically by the formulae of Lehmann-Filhés.* Changes were then made in the derived elements, after comparing with the curve given by the observations, and several sets of elements tested by the observation values. It is the opinion of the writer that the application of the method of least squares to stars of this type of spectrum and number of lines will not be warranted, except in the case that a large number of observations are available extending over a long interval of time. With some experience in the method it is possible in a relatively short time to test and change the elements given by the graphical solution until the resulting values would be little if any bettered by a least-square solution. The computation of even three or four test ephemerides involves much less labor and time than a least square solution.

* *A. N.*, 136, 17, 1894.

By such methods the following set of elements was decided upon as best satisfying the data furnished by the observed radial velocities:

ELEMENTS OF α PAVONIS.

Peroid = 11.753 days

$e = 0.01$

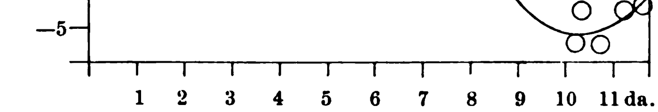
$K = 7.25$

$T =$ J. D. 2416379.90

$\omega = 224°.80$

Velocity of system = +2.0 km.

$a \sin i = 1{,}170{,}000$ km.



VELOCITY CURVE OF α PAVONIS.

The total range in the radial velocity is only 14.5 kilometers. The observations are about as well satisfied by a circular orbit, as the eccentricity is evidently very small.

This velocity curve and the separate observations are plotted in the accompanying diagram, the dotted line, as usual, representing the velocity of the center of mass of the system. The numerical values of the residuals secured by comparison of the observed radial velocities with an ephemeris computed from these elements is given in the final column of the observation table.

THE D. O. MILLS EXPEDITION,
SANTIAGO, CHILE, August, 1907.

ORBIT OF THE SPECTROSCOPIC BINARY κ VELORUM

The binary nature of κ *Velorum* ($\alpha = 9^h\ 19^m0$; $\delta = -54°\ 35'$) was discovered by Professor W. H. Wright in the work of the D. O. Mills Expedition to the Southern Hemisphere.* The star is given in the Harvard classification as Type B3A; its visual magnitude is 2.6. The following six lines are the only ones usable in the portion of spectrum given by the spectrograph of the Mills Expedition:

λ 4267.316	C
4340.634	H
4388.100	He
4437.718	He
4471.646	He
4481.400	Mg

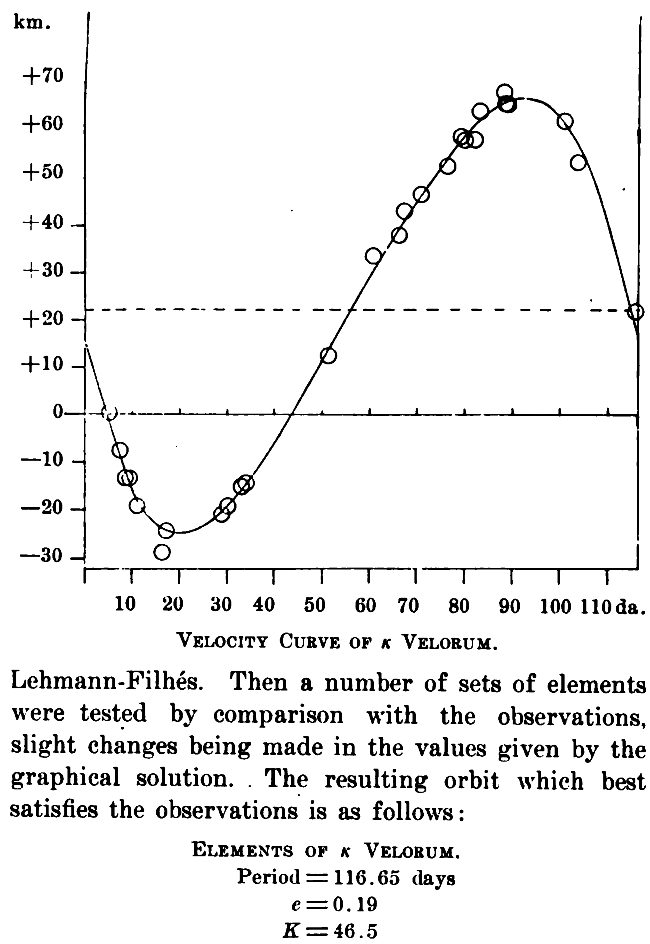
Of these lines the helium line at λ 4437 is generally faint and was not usable on a number of the plates. In addition to these lines exceedingly faint traces of a number of the oxygen lines of the β *Crucis* type are discernible on a few of the plates; these lines were never distinct enough to use.

The orbit depends upon the following twenty-seven plates:

No.	Plate	G.M.T.	Vel.	Measurer	O.–C.
1	216 I	1904, Mar. 6.739	+70 km. +66.8	Palmer Wright	+2.4
2	535 II	1905, Jan. 14.703	+12.9	Palmer	—2.0
3	602 II	Feb. 20.651	+65.7	Palmer	—0.7
4	618 III	Mar. 7.601	+53.3	Palmer	—3.6
5	1052 III	1907, Jan 11.844	+58.6	Curtis	+2.3
6	1057 II	Jan. 12.788	+57.9	Curtis	—1.1
7	1065 II	Jan. 14.829	+58.5	Curtis	—2.7
8	1072 IV	Jan. 15.824	+64.8	Curtis	+2.6
9	1085 III	Jan. 21.788	+65.8	Curtis	—0.8
10	1129 II	Feb. 2.790	+62.0	Curtis	+0.4
11	1194 II	Mar. 19.534	—21.0	Curtis	—0.5
12	1198 II	Mar. 20.556	—19.2	Curtis	+0.2
13	1200 III	Mar. 23.570	—15.2	Curtis	+0.4
14	1207 III	Mar. 24.545	—14.5	Curtis	+0.5
15	1256 III	April 20.591	+33.8	Curtis	+3.3
16	1264 III	April 25.572	+38.2	Curtis	—0.8
17	1270 III	April 26.555	+43.2	Curtis	+2.6
18	1283 III	April 30.480	+46.7	Curtis	—0.2
19	1300 II	May 5.494	+52.7	Curtis	—1.4
20	1364 III	June 14.466	+22.1	Curtis	+3.7
21	1366 II	June 19.463	+ 0.3	Curtis	+0.3
22	1377 I	June 22.470	— 7.6	Curtis	+1.0
23	1384 I	June 23.479	— 8.8	Curtis	+2.5
24	1390 I	June 24.463	—13.3	Curtis	+0.5
25	1397 I	June 26.457	—19.2	Curtis	—1.4
26	1402 I	July 1.451	—28.2 —29.9	Curtis Curtis	—4.8
27	1408 I	July 2.460	—23.9 —25.1	Curtis Curtis	+0.2

* *Lick Observatory Bulletin*, 3, 111, 1905.

A preliminary orbit was computed graphically from these values in accordance with the formulae of



VELOCITY CURVE OF κ VELORUM.

Lehmann-Filhés. Then a number of sets of elements were tested by comparison with the observations, slight changes being made in the values given by the graphical solution. The resulting orbit which best satisfies the observations is as follows:

ELEMENTS OF κ VELORUM.

Period = 116.65 days
$e = 0.19$
$K = 46.5$
$T =$ J. D. 2416459.00
$\omega = 96°23$
Velocity of system = +21.9 km.
$a \sin i =$ 73,200,000 km.

These elements are represented by the curve of the accompanying diagram, where the dotted line gives the velocity of the center of mass of the system. The total range in the velocity is ninety-three kilometers. It is to be expected that future observations may change the value of the period slightly, as the observation period covers only about fourteen revolutions of the system. An ephemeris computed from these elements gives the residuals, observed minus computed, which are tabulated in the last column of the table of observations.

THE D. O. MILLS EXPEDITION,
SANTIAGO, CHILE, August, 1907.